WAPORA, Inc. Environmental/Energy/Economic Studies
4348 RIVERLINE DRIVE, EARTH CITY, MISSOURI 63045
PHONE (314) 291-8484

Project 1526

LEVEL II

7 December 1981

AQUATIC BIOLOGICAL INVENTORY,
HARTWELL DRAINAGE AND LEVEE DISTRICT
GREENE COUNTY, ILLINOIS

Submitted to:

St. Louis District
Corps of Engineer
210 Tucker Blvd., North
St. Louis, MO 63101

Prepared by:

Richard N. Kubb
Associate Biologist

Approved by:

Richard W. Gill
Manager, St. Louis Office

John P. Johnson (fax)
John P. Johnson
Regional Director

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The primary objective of this study was to identify and provide a qualitative evaluation of the aquatic habitats associated with the Hartwell District. A secondary objective included quantification of key physical and biological parameters at specific sampling locations within the study area. These data were used to support statements regarding the quality of the aquatic habitats of the Hartwell District.

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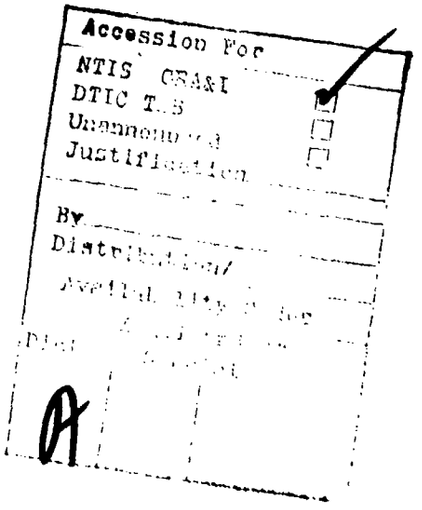

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1.0 INTRODUCTION

The Flood Control Act of 23 October 1962, Public Law 87-874 authorized construction of a comprehensive plan of improvement for flood protection and other purposes in the Illinois River and Tributaries Basin. This plan of improvement was in accordance with the recommendations of the Chief of Engineers in House Document Number 472, Eighty-Seventh Congress, 2nd session. The Hartwell Drainage and Levee District is one of 16 local flood protection projects recommended for improvements.

A General Design Memorandum-Phase 1, Plan Formulation, for the Hartwell Drainage and Levee District, Greene County, Illinois is in preparation. Included in Phase 1 is a planning document, providing environmental information to be considered in the identification of alternative solutions to water resource problems and opportunities associated with the Hartwell District. This report provides a qualitative and quantitative evaluation of the aquatic habitats located in the Hartwell District and will be used as part of the Phase 1, Environmental Planning Document. The primary objective of this study was to identify and provide a qualitative evaluation of the aquatic habitats associated with the Hartwell District. A secondary objective included quantification of key physical and biological parameters at specific sampling locations within the study area. These data were used to support statements regarding the quality of the aquatic habitats of the Hartwell District.

2.0 MATERIALS AND METHODS

2.1 Study Area

The Hartwell Drainage and Levee District, Greene County, Illinois, is located on the East bank of the Illinois River between River Mile 38.2 (the mouth of Apple Creek) and River Mile 43.1 (the mouth of Hurricane Creek). The district consists of 9,630 acres of primarily agricultural land. The district is protected by 5.0 miles of riverfront levee and 7.2 miles of flank levee. Lentic (standing water) habitats within the district consist of a single swamp located in the southwest corner of the district and a single small pond. Lotic (flowing water) habitats consist of 3 major drainage ditches and several lateral or interconnecting ditches that drain the croplands within the district. Within these drainage ditches, flow is directed south and west toward a single pump house located near the mouth of Apple Creek. There, water is discharged into the Illinois River. Apple Creek runs along the southern border and Hurricane Creek runs along the northern border of the district.

2.2 Literature Review and Consultation

All readily available reports and documents related to the aquatic biological resources within the Hartwell District and nearby areas were obtained and reviewed. In addition, the following selected individuals with extensive knowledge of the study area were contacted and interviewed:

Person	Location	Phone
Mr. Joe Janecek	U.S. Fish & Wildlife Service	(618) 457-3662
Mr. Dick Lutz	Illinois Dept. of Conservation	(217) 782-3884
Dr. Richard Sparks	Illinois Natural History Survey	(309) 543-3950
Dr. Jamie Thomerson	Southern Illinois Univ.-Edwardsville	(618) 642-3368

Each individual was asked of his knowledge and professional interest related to the aquatic biological resources within the Hartwell and nearby Levee Districts. Results of pertinent literature findings and interviews with local authorities were then summarized.

2.3 Photo-interpretation and Habitat Mapping

A series of 1979 true-color aerial photographs (1:1200) of the Hartwell District was reviewed to identify dominant aquatic, wetland, and terrestrial habitats located within the Hartwell District. These habitats were outlined on a topographic map (1:24,000) and transferred to a base map (1:14,400). This map is included in the report as a detached Figure. Acreage values of standing water and lengths of streams and ditches were measured with a Lasico Model L-10 Planimeter using the topographic map.

2.4 Aquatic Habitat Evaluation

A joint field reconnaissance/biological survey was conducted between 29 July and 11 August 1981 in order to assess the quality of the aquatic habitats within the study area. Each of the major lotic (flowing) and lentic (standing) aquatic habitats were observed along random points. Observations of lotic habitats included: stream width, depth, bottom type, flow, instream cover, aquatic vegetation, and streamside cover. Information gathered on lentic habitats included: acreage, shoreline length, depth, shoreline vegetation, aquatic vegetation, bottom sediments, and occurrance of impounded cover.

In addition to field observation, biological samples and water quality measurements were gathered at ten specific sampling locations. Six stations were located within major or lateral ditches, two stations were established at each of the flanking creeks, one station was located in a swamp, and one station was a small pond. Biological samples included phytoplankton, zooplankton, benthic macroinvertebrates, and fisheries. Water quality parameters measured included depth, water clarity, turbidity, temperature, dissolved oxygen, and conductivity.

2.4.1 Water Quality Parameters

Water depth was measured using a Lowrance depthsounder. Water clarity was measured with a standard secchi disc. Turbidity was measured with Hach turbidity meter. Temperature and dissolved oxygen were measured with a YSI Model 54-A oxygen meter. Conductivity was measured with YSI Model 33 S-C-T meter. Flow was measured by time of travel of floating debris over a known distance.

2.4.2 Biological Parameters

Phytoplankton, zooplankton, and benthic macroinvertebrate samples were collected and analyzed from each of the 10 sampling stations. Fish collections were made at 9 of the 10 sampling stations. Fish collections were not made at Station 8 (swamp). Thick masses of emergent vegetation in the swamp innibited effective seining and there was no available open water access to launch a boat equipped with electrofishing gear.

2.4.3 Phytoplankton

A single phytoplankton sample was collected at each of the stations. Each sample consisted of all organisms found in 4 liters of water, concentrated by sedimentation. Phytoplankton samples were preserved in the field with 4 ml of Volvox fixative per 100 ml of sample (Cave and Pocock 1956) and transported to the laboratory.

Phytoplankton identification and enumeration was conducted using Wild M-40 and Olympus BHB phase contrast microscopes. Taxonomic references used to identify the plankton are listed in Table 1.

The Utermohl (1958) method of sample analysis described by Weber (1973) was utilized. This method was chosen because the sample material receives a minimum of handling and the sampling and analytical protocol includes the nannoplankton.

Counting procedures followed those outlined in Biological Field and Laboratory Methods for Measuring the Quality of Surface Waters and Effluents (Weber 1973). Generally, at least two strips (perpendicular to each other) across the bottom of the chamber were counted. The volume of water sedimented was adjusted to yield counts that included at least one hundred of the most abundant taxa. Organisms enumerated were identified to the species level when feasible. Taxa not identified to the species level were differentiated to allow for the calculation of diversity indices. Data obtained from counts were entered in a computer. Computer generated tables included density and percent occurrence of major groups and individual taxa, number of taxa, and the Shannon-Wiener diversity index (Krebs 1972) for each replicate sample.

2.4.4 Zooplankton

Zooplankton samples were collected in conjunction with phytoplankton samples at each of the ten sampling locations. A single sample was collected at each station consisting of thirty liters of water bucketed through a number 25 (64μ) mesh plankton net. The concentrated samples were each transferred to individual labeled bottles, preserved in a 5% formalin concentration, and returned to the laboratory for analysis.

Zooplankton analysis was conducted utilizing a compound microscope and a standard Sedgewick-Rafter counting chamber. Three replicate one ml alequots of sample concentrate were examined per sample and the numbers of zooplankton were converted to density per liter of water sampled by the following formula from Weber (1973):

$$\text{No./l} = \frac{T \times C}{S \times V}$$

Where:
- T = Total tally
- C = Total volume of sample concentrate (ml)
- S = Volume of sample examined (ml)
- V = Volume of water sampled (liters)

Table 1. Taxonomic references used to identify phytoplankton samples from the Hartwell District. References are listed according to major taxonomic groupings.

Taxonomic Group	References
Diatoms	Weber (1966); Patrick and Reimer (1966); Patrick and Reimer (1975); Hustedt (1961-1966); Hustedt (1959); Hustedt (1930); Huber-Pestalozzi (1938)
Cryptophyta	Huber-Pestalozzi (1968)
Euglenophyta	Huber-Pestalozzi (1955)
Chrysophyta	Huber-Pestalozzi (1941)
General	Smith (1950); Prescott (1962, 1970); West and Fritsch (1968); Taft and Taft (1971); Tiffany and Brittan (1971)

Adult copepods and cladocerans were identified to species and rotifers to genus when possible. Taxonomic references included, but were not limited to, Ahlstrom (1940, 1943), Brooks (1957), Edmondson (1959), and Pennak (1953).

Zooplankton counts by individual taxa were recorded on standard WAPORA bench sheets with each taxa assigned a code number for computer entry and print-out.

2.4.5 Benthic Macroinvertebrates

Five quantitative benthic samples were collected at each of the ten sampling locations. Each sample consisted of all organisms collected in a 0.03 square meter Ponar grab sample and retained by a No. 30 seive. Each sample was placed in a labeled quart jar. All organisms were preserved in 10% formalin and transported to the laboratory for analysis.

Each sample was poured into a sorting tray and all organisms were removed and placed in individual labeled vials. Oligochaetes and members of the family Chironomidae were mounted on slides and cleared using CMC-10 mounting media (Parrish 1975) for easier viewing of anatomical structures. All organisms were identified to the lowest practical taxon. References used in identifying the Chironomidae included Hilsonhoff (1975), Brinkhurst et al. (1968), Mason (1973), Oliver et al. (1978), Simpson and Bode (1978), and Parrish (1975). References used in identifying members of the Naididae and Tubificidae included Hiltuner (1973) and Howmiller (1975). The Ephemeroptera (mayflies) were identified using Burks (1975). The Trichoptera (caddisflies) were identified using Ross (1944). Other general references helpful in identification of benthic macroinvertebrates included Edmonson (1959), and Pennak (1953).

Computer coded data sheets for each sample complete with taxonomic information as well as depth and substrate information were entered into a Harris Model 80 minicomputer for data processing. Taxonomic listings were prepared for each sampling station. The density of each taxon and the total macroinvertebrate density in numbers per square meter was computed for each sample replicate and the arithmetic mean was computed for each sampling station. Species diversity indices using the Shannon-Wiener index were computed.

2.4.6 Fish

Adult fish collections were made at each sampling location excluding Station 8 (swamp). At seven of nine stations a known area was partitioned using 60 feet long by 8 feet deep block nets. Length of the stations ranged from 30 feet to 50 feet. Block nets were not used at Station 7 (pond) and Station 10 (Hurricane Creek). At Station 7 a one hour electrofishing sample was collected along the nearshore of approximately 1/2 of the pond circumference. At Station 10, swift current inhibited the use of block nets and only seining was conducted. At each of the other stations electrofishing or a combination of both electrofishing and seining techniques were used.

Electrofishing gear included a 220 volt AC generator mounted in a 14-foot Jon boat equipped with two lead electrodes extending into the water to a depth of about 4 feet. At each station, electrofishing was conducted for at least a 1 hour period. Following the initial 1 hour period, electrofishing was continued for a period of 10 minutes following the final fish capture, to ensure

that all fish (fish susceptible to AC shocking) in the enclosed area were removed. Complete removal of fish may not have occurred at stations when maximum depth exceeded 5-6 feet since the electrofishing is generally less effective in deeper water. Seining was also conducted at sampling stations when possible. Steep sloping banks and deep water at several of the stations inhibited effective seining. Seining was not conducted at stations 3, 5, 6, and 7. At each station, fish were removed and placed in a wash tub partially filled with water. Following the sampling period each fish was identified to species. Total length and weight was recorded for each fish.

Computer coded data sheets including length and weight information for each fish species were entered into a Harris model 80 minicomputer for data processing. Computer data tables were generated summarizing fish information for each sampling station. Standing crop in pounds per acre of each fish species was estimated for a station when feasible. Species diversity indices were computed using the Shannon-Wiener index (Krebs 1972).

References used in the field for identification of fish included Smith (1979) and Pflieger (1975). Fishes that could not be readily identified in the field were returned to the laboratory. These included young-of-the-year and larval specimens.

3.0 RESULTS AND DISCUSSION

3.1 Literature Review

The aquatic biological resources of Illinois have been thoroughly investigated through the cooperative efforts of researchers within governmental agencies and universities. Illinois fisheries have been well documented. Smith (1971) classified the streams of Illinois based on habitat types and their associated fish compositions. Smith (1965) prepared an annotated list of the Illinois fishes and followed (Smith 1979) with a more detailed taxonomic treatment of the fishes of Illinois. Mills et al. (1966) documented biological modifications (major emphasis on fishes) that have occurred in the Illinois River over a period of 75 years as a result of human influence. Similarly, Larimore and Smith (1963) reported the long term effects of stream changes on the fishes in Champaign County, Illinois. Lopinot (1967) conducted an inventory of the fishes from nine streams within the Macoupin Creek Basin of Illinois.

Several authors have published material on the aquatic macroinvertebrates of Illinois. Frison (1935) contributed a detailed taxonomic analysis of the Plecoptera (stoneflies) of Illinois. Ross (1944) presented work on the taxonomy and distribution of the Trichoptera (caddisflies) of Illinois. A thorough treatment of the Ephemeroptera (mayflies) was given by Burks (1953). The Anisoptera (dragonflies) of Illinois are described by Needham et al. (1903) and the Zygoptera (damselflies) are presented in Garmen (1917). The Dipteran Chironomidae (midges) of Illinois are described in Mallock (1915) and the Culicidae (mosquitoes) are treated in Ross (1965). Freshwater mussels in Illinois have been investigated by Lopinot (1968), Starrett (1971), and Parmalee (1967).

Phytoplankton in Illinois waters has been studied by several authors. Tiffany et al. (1971) contributed the Algae of Illinois. Lin et al. (1978) investigated the distribution of algae in Illinois streams. Morris et al. (1978) reported on the distribution of phytoplankton in Illinois lakes. Kofoid (1903, 1908) reported the taxonomic distribution of zooplankton in the Illinois River and surrounding watershed.

For a description of the aquatic and semi-aquatic amphibians and reptiles of Illinois see Smith (1961) and Cahn (1937).

Several localized aquatic biological surveys in the area near the Hartwell Drainage and Levee District have been conducted. Thomerson (1977) surveyed the fish and macroinvertebrates of the Eldred and Spanky Drainage and Levee District. Kulfinski (1977) studies the algal and vegetative components of the same district. Axtell (1981) conducted an aquatic biological inventory of the Nutwood Drainage and Levee District. A similar aquatic study is currently being conducted within the Hillview District (adjacent to Hartwell-North).

Recent fishery surveys in the Illinois River near the Hartwell study area have been conducted by the Illinois Natural History Survey (Sparks 1975). These surveys have been primarily by electrofishing. Other fish surveys within Greene, Jersey, and Scott Counties have been conducted by the Illinois Natural History Survey and are available as unpublished data.

The Illinois Department of Conservation published fishery data for Greene, Jersey, and Scott Counties as part of a survey on the Water Resources of these Illinois counties (Lockart 1971a, 1971b; and Rogers 1980). The Illinois DOC has also recently published the results of a statewide sport fishery survey for fiscal year 1978 (Rogers 1980).

3.2 Consultation

Individuals with extensive knowledge of the aquatic biological resources within the study area were contacted and interviewed.

Dr. Richard Sparks of the Illinois Natural History Survey was contacted on 24 July 1981. He was informed that WAPORA was conducting an aquatic biological inventory of the Hartwell District. Dr. Sparks explained that the Ill. Nat. Hist. Surv. team has not previously conducted surveys in the drainage areas and that they are generally not concerned with the biota located behind the levees, but maintain a deep interest in the Illinois River mainstem and tributaries.

Mr. Joe Janecek of the US Fish and Wildlife Service (USFWS) was contacted on 3 August 1981. He was aware of the current study and informed WAPORA of USFWS's role in providing fish sampling and data analysis recommendations to the St. Louis Corp of Engineers. We discussed the various fish sampling methods (electrofishing, seining, etc.) used in this study. Mr. Janecek sent to WAPORA a copy of a letter sent to Owen Dutt from him that described in detail the recommendations made by USFWS.

Mr. Dick Lutz of the Illinois Department of Conservation (DOC) was contacted on 30 September 1981. Mr. Lutz expressed that due to limited manpower, little aquatic biological sampling with the various drainage and levee districts has been done by the Illinois DOC. Higher priority is given to the major Illinois rivers, tributaries, and lakes. He mentioned that he would check the DOC's data files for possible information on the aquatic biota of the Hartwell District.

Dr. Jamie Thomerson of Southern Illinois University-Edwardsville was contacted on 30 September 1981. He agreed to send WAPORA a copy of his report on the fishes and macroinvertebrates occurring in the Eldred and Spanky Drainage and Levee District. Dr. Thomerson mentioned that some of the areas sampled in the Eldred and Spanky District supported a largemouth bass fishery as evidenced by capture of small young-of-the-year basses. He mentioned that other areas supported only fathead minnows and black bullheads. He felt that these areas were isolated or choked off and that previous "hard winters" may have killed off other species. He mentioned that some of the small streams flowing down from the bluffs supported a wide diversity of fishes. Dr. Thomerson utilized DC electrofishing gear and seining. He mentioned that in some locations deep water and steep sloping banks inhibited the effectiveness of seining. Also, in a few areas, hard water conditions limited the effectiveness of the electroshocking gear.

In addition to the above consultants, several local residents with knowledge of the aquatic biological resources within the Hartwell District were contacted. Mr. Jim Powell, district commissioner of the Hartwell District was contacted on 1 October 1981. Mr. Powell explained that many local and nearby residents utilize the main ditches and the pond within the Hartwell District for recreational fishing. He mentioned that some of the ditches maintained populations of white crappie, bluegill, and bullheads. He considers the pond to be primarily a bass pond and that fishing pressure in general within the district is heavy. Mr. Powell explained that the swamp (Brushy Lake) located in the southwest corner of the district does not support a sport fishery. It is shallow and choked with vegetation. He along with many of the local residents consider Brushy Lake to be of considerable value as waterfowl habitat. The privately owned area is leased to a local duck hunting club (Brushy Lake Duck Club) and hunting pressure there is heavy. Mr. Powell mentioned that the owner of Brushy Lake has considered draining the swamp for farmland following the termination of the lease (end of current year). Mr. Powell and others are concerned over the potential loss of this waterfowl habitat.

Mr. Bob Witzer, the president of Brushy Lake Duck Club, was contacted 1 October 1981. He expressed similar feelings toward Brushy Lake as a valuable waterfowl and wildlife resource.

Mr. Charlie Young was contacted on 8 August 1981. Mr. Young is a Drag line operator for the Hillview Drainage and Levee District. Mr. Young explained that the ditches are dredged on a regular basis. Time between dredgings is usually 1 to 2 years. He explained that in the dragline dredging process, the vegetation adjacent to the ditches is destroyed and covered over by dredge spoil from the ditches. He mentioned that the Hartwell District is used by many local residents for recreational fishing.

3.3 Overview of Aquatic Habitats

Although the major land use in the Hartwell Drainage and Levee District is agricultural, several aquatic habitats have been identified. There are major and lateral ditches, a shrub swamp, and a small pond. Small creeks are located adjacent to the north and south borders of the district (see Table 2a,b).

3.3.1 Lotic Systems

The majority of flowing water in and adjacent to the district consists of three major drainage ditches and associated lateral ditches (Table 3). A total of 27 miles of drainage ditches occurs within the district. The estimated total ditch area is 86 acres. A-Ditch is 4.3 miles long and runs north-south on the east side of the district. It is fed initially by a creek flowing down from the bluffs immediately adjacent to the district and by several smaller lateral ditches along the eastern border of the district. A total of five creeks drain down from the eastern bluffs into channelized lateral ditches and into A-Ditch (See detatched Figure). The average width of A-Ditch within the upper and middle reaches is about 35 feet. Streamside vegetation along these reaches consists mainly of perennial grasses, regweeds, and small maple and willow trees. In the southern third of the district A-Ditch cuts west and flow is directed toward the pump house in the southwest corner. In this lower reach, A-Ditch widens to an average width of 55 feet. Along this lower reach the area is heavily wooded with large stands of cottonwoods, willows, and sycamores lining both shorelines. This is the only significant bottomland forest occurring adjacent to ditches in the district and has resulted from the prohibition of lumbering by private ownership. In this lower reach, numerous tree falls, stumps, and large branches occur in the ditch providing shade and cover.

B-Ditch (known as Long Lake by local residents) is 4.2 miles long and originates in the north central area of the district. It flows south and west into C-Ditch. The upper reach of B-Ditch averages 20 to 30 feet wide and 3-5 feet deep. Streamside vegetation is mainly grasses, with some single row stands of bottomland hardwoods. The middle reach of B-Ditch meanders slightly to the west and back to the south. The ditch is wider here (40 feet) and slightly deeper (4-6 feet). Bottomland forest stands are greater in number and size along this middle reach. The lower reach of B-Ditch flows west into C-Ditch. The habitat in this reach is similar to the middle reach. Four smaller lateral ditches take on runoff from the croplands in the center of the district and drain into B-Ditch.

D-Ditch is 4 miles long and originates in the northwest area of the district and flows due south into A-Ditch. The uppermost reach of C-Ditch is narrow (20 feet) and shallow (3-4 feet) and serves to drain immediate adjacent croplands. Streamside vegetation along this reach is sparse, consisting of mainly grasses. The middle reach of C-Ditch is wider (40 feet) and deeper (5-7 feet) and accepts drainage from several lateral ditches. Single and double rows of bottomland trees lie in patches adjacent to the ditch providing some shade and cover. The lower reach of C-Ditch is between 40 and 50 feet wide and about 5-7 feet deep. Intermittent stands of willows, small cottonwoods, and maples occur alongside this reach. C-Ditch merges with A-Ditch in the southwest corner of the district where flow is directed toward the pump house and into the Illinois River (See detached Figure).

Table 2a. Hartwell Drainage and Levee District land use expressed in acreage and percent of total acreage.

Habitat	Area (acres)	Percent of Total Acreage
Urban (1)	65	0.7
Cultivated Field	8905	92.5
Old Field	84	0.9
Bottomland Forest	201	2.1
Shrub Swamp	87	0.9
Pond	3	0.03
Border Habitat(2)	191	2.0
Ditches	86	0.9
Emergent	8	0.08
Total	9,630	

(1) Includes farmsteads, roads and other development.

(2) Includes successional ditch-side vegetation and road-side vegetation. Not depicted on map because of narrow width (Average width 10-20 feet)

Table 2b. Habitats and acreages located outside the protection of the Levee, between the Levee and the Illinois River, Hurricane Creek and Apple Creek.

Habitat	Area (acres)
Bottomland Forest	360
Streams	42
Total	402

Table 3. Major lotic environments located within and adjacent to the Hartwell Drainage and Levee District

Drainage	Length (miles)	Average Width(ft)	Surface Acres	Sinuosity	Average Depth(ft)	Instream Cover (1)	Streamside Cover (2)	Aquatic Vegetation (3)	Bottom Type (4)	Flow (ft/sec) (5)
A-Ditch	4.3	40	20.8	1.1	5	TF,UB	PE,M	SP	SI,CL	SL
B-Ditch	4.2	30	15.3	1.2	5	—	PE,US	SP	SI,CL	SL
C-Ditch	4.0	35	17.0	1.1	5	TF	PE,M	SP	SI,CL	SL
Lateral Ditches	14.8	20	35.9	—	2-4	—	PE,US	SP	SI,CL	SL
Subtotal	27.3		89.6							
Apple Creek	5.0	50	30.3	1.68	6	TF,UB	M	SP	SI,SA,CL	<1
Hurricane Creek	3.8	25	11.5	1.1	4	—	PE	SP	SI,SA,GR	1-1.5
Subtotal	8.8		41.8							
TOTAL	36.1		130.8							

(1) TF = Tree Falls
UB = Undercut Banks

(2) US = Understory
PE = Perrenials
M = Mixed Timbers

(3) F = Floating
E = Emergent
SP = Sparse

(4) SI = Silt
CL = Clay
SA = Sand
GR = Gravel

(5) SL = Sluggish

Apple Creek and Hurricane Creek are located adjacent to the respective southern and northern borders of the district. Apple Creek is approximately 5 miles long and averages 50 feet wide and 5-6 feet deep. Generally, Apple Creek is a slow moving stream. The bottom is laden with silt and clay with patches of fine sand occurring intermittently. Numerous tree falls and stumps occur in Apple Creek providing instream cover. Apple Creek has been channelized with most of the original meander removed. Still, some stream curvature remains in the upper reach of the creek. The middle and lower reaches have been straightened (See detached Figure). The sinuosity index for Apple Creek is 1.58 and is the highest of all streams and ditches within the district. Large stands of bottomland forest are present adjacent to Apple Creek along the middle and lower reaches. Aquatic vegetation is sparse. Seasonal flooding occurs along the banks of Apple Creek. During July 1981, following several large storms, it was observed that Apple Creek had exceeded its banks by 1 to 2 feet. During this same period, Hurricane Creek along the northern boundary of the district had remained within its banks.

Hurricane Creek is approximately 3.8 miles long adjacent to the district. This creek has been channelized and straightened. The sinuosity index for Hurricane Creek is 1.1. There are no naturally occurring meanders. Hurricane Creek is approximately 20-30 feet wide and averages about 3-5 feet deep. Bottom types ranges from silt and clay to coarse sand, gravel, and some cobble in the eastern reaches. Flow in Hurricane Creek is generally swifter than in Apple Creek and ranges from sluggish in the lower reach to moderate in the upper reaches. A series of riffles and deeper pool areas exist in the upper reaches of the creek. Streamside vegetation consists of mainly grasses and small perennial shrubs in the upper and lower reaches. Within the middle reach, larger bottomland trees occur in patches. Aquatic vegetation is sparse.

3.3.2 Lentic Systems

Brushy Lake (swamp) and Sand Hole (pond) represent the only permanent standing water areas within the Hartwell District. Brushy Lake is an 87 acre shrub swamp located in the southwest corner of the district. The soils are permanently submerged. The dominant emergent plants are shrubby hydrophytes. Large stands of both dead and live timber (cottonwood, ash, etc.) occur in the swamp (Table 4).

Water levels in the swamp are maintained by groundwater seepage from the adjacent levee; the source being the Illinois River. During the fall, when the Illinois River is low, water is pumped into the swamp to maintain constant water levels. This water level manipulation is carried out by members of the Brushy Lake Duck Club in order to preserve the swamp habitat. The Brushy Lake Duck Club maintains five duck blinds in the swamp. Each blind is located near a small patch of shallow, open water. These open water areas are maintained by periodic clearing of emergent vegetation and provide excellent habitat for waterfowl.

Sand Hole is a small 3 acre pond located in the north-central area of the district. The average depth is approximately 8 feet and the maximum depth is 12 feet. The bottom sediments vary from fine silt and clays in the deeper areas to fine to medium sand in shallower portions of the pond. Several small springs feed the pond. Aquatic vegetation consists of mainly floating plants

Table 4. Major lentic environments located within the Hartwell Drainage and Levee District

Name	Acreage	Shoreline Length (ft)	Average Depth (ft)	Maximum Depth (ft)	Shoreline Vegetation (1)	Aquatic Vegetation (2)	Bottom Type (3)	Impounded Coves (4)
Brushy Lake (shrub swamp)	87	6,300	3-4	6	US,M	F,E	DE,MA	ST,TF
Sand Hole (Pond)	3	675	8	12	US,M	F,E	SI,SA CL	TF
TOTAL	90	6,975						

(1) US = Understory
M = Mixed Timber

(2) F = Floating
E = Emergents

(3) SI = Silt
CL = Clay
SA = Sand
DE = Detritus
MA = Matted Vegetation

(4) TF = Tree Falls
ST = Standing Trees

with some emergents, including cattails and buttonbush. A well developed stand of bottomland trees surrounds the pond. Large cottonwoods, willows, and ash predominate. Numerous tree falls, sunken stumps, and brush exist in the pond and provide cover for aquatic organisms.

3.4 Existing Aquatic Biological Resources

Fisheries, macroinvertebrates, and plankton data were gathered from 10 sampling locations within and adjacent to the district in order to document existing conditions and assess the overall value of these components as biological resources.

3.4.1 Fisheries

Habitats capable of supporting fish life in the study area include the major and lateral drainage ditches, Apple Creek, Hurricane Creek, and Sand Hole Pond. Brushy Lake probably supports limited fish resources but this area was not sampled and it is known that it is not used for recreational fishing by local residents (see Table 5 for physical data).

A total of 306 fish representing 21 species were collected in the study area. Total weight of the catch was 48.1 lb. The combined sampling area over all sampling sites was 18,000 square feet. Average biomass per acre was estimated at 116 pounds/acre (see Appendix table A.2). Numbers of fish captured and estimated biomass/acre for each species and sampling location are presented in Table 6 and 7.

The dominant fishes occurring within the Hartwell District are considered wide ranging species, tolerant of wide fluctuations in environmental conditions including temperature, dissolved oxygen, flow, turbidity, and siltation. Nine of the 21 species belong to this ecological group: gizzard shad, carp, golden shiner, black bullhead, green sunfish, bluegill, spotted bass, largemouth bass, and white crappie. A second ecological assemblage of fishes, typical of prairie regions (defined in Pflieger 1975), was also found within the study area. These included hornyhead chub, bigmouth shiner, red shiner, suckermouth minnow, and bluntnose minnow. Warmouth and brown bullhead were also collected and are considered lowland species. Big river fishes taken in the collections included freshwater drum, bigmouth buffalo, quillback, and shortnose gar. For a general discussion of these fish faunal assemblages see Pflieger (1975) and Thomerson (1977).

The drainage ditches within Hartwell are typically shallow, ranging in depth from 2 to 6 feet, with shallow gradients. They are sluggish, usually moderately to highly turbid and with low to moderate levels of dissolved oxygen. Turbidity in the ditches ranged from 75 to 160 FTU units and secchi readings ranged from 0.4 to 1.5 feet (Table 3). Dissolved oxygen ranged from 2.9 to 6.7 ppm. Rough fish typically dominate these habitats, although sport fishes can occur in restricted areas. Carp was the dominant fish in terms of biomass collected in the Hartwell drainage ditches. Biomass values ranged from 49 lb./acre to 122 lb./acre and averaged 56 lb./acre (Table 7). Gizzard shad was the dominant forage fish found in the ditches. This species averaged 21 lb./acre over the six ditch sampling stations. Largemouth bass was found in three of the six ditches. Individual bass captured were of fairly good size and in good condition. Bass averaged 13 inches in total length and

Table 5. Summary of physical parameters measured at each of ten sampling locations during a joint Field Reconaissance/Biological Survey of the Hartwell Drainage and Levee District.

	Lentic Systems		Lotic Systems							
	Swamp Brushy Lake	Pond Sand Hole	Ditches						Apple Creek	Hurricane Creek
Station No.(Fig. 1)	8	7	1	2	3	4	5	6	9	10
Physical Parameters										
Ave. Width, ft.			55	40	35	40	45	40	55	30
Depth, ft.										
Average	3	9	6	6	5	7	5	5	4	4
Maximum	5	12	8	8	7	7	7	7	6	6
Secchi, ft	1.1	1.8	1.5	0.4	1.8	0.4	0.9	1.1	0.7	0.7
Turbidity, FTU	85	65	75	140	120	160	130	130	140	158
Temperature, ^{0}C	21.5	26.0	23.5	21.4	22.0	20.2	22.0	20.5	23.0	22.0
Dissolved Oxygen	4.1	7.6	3.6	3.3	2.9	3.4	6.4	6.7	5.5	8.2
Conductivity, umhos	135	170	550	293	600	125	640	555	450	400
Bottom Type	Detritus	Sand/ Silt	Silt	Clay/ Silt	Silt	Silt	Clay	Sand/ Clay	Silt/ Sand	Sand/ Gravel

Table 6. Total numbers of fish collected within and adjacent to the Hartwell Drainage and Levee District during a Biological Sampling Survey conducted between 29 July and 11 August 1981.

	Lentic Systems	Lotic Systems							
	Pond Sand Hole	Ditches						Apple Creek	Hurricane Creek
Station No.	7	1	2	3	4	5	6	9	10
Species									
Shortnose gar								1	
Gizzard shad		6	15	20	14	6	8	10	
Carp	5	4	3	3	5		2	4	
Hornyhead chub									4
Golden shiner			1						1
Emerald shiner									1
Bigmouth shiner									7
Red shiner								2	10
Suckermouth minnow									1
Bluntnose minnow									5
Carp fry								50	
Quillback								1	
Bigmouth buffalo									1
Black bullhead			1						
Brown bullhead					1				3
Sunfish fry				2	2	1			
Green sunfish				1		2	1	3	
Warmouth						1	2		
Bluegill	9	4	8	2	8	15	20	3	1
Spotted bass							1		2
Largemouth bass	2		1	2		1			
White crappie		3			11	1	1		
Freshwater drum								1	
Totals	16	17	29	30	41	27	35	75	36
Total Species	3	4	6	6	6	7	7	9	11
Shannon-Wiener Index	1.03	1.35	1.28	1.16	1.53	1.34	1.29	1.22	2.06

Table 7. Estimated Biomass (pounds/acre) of fish occurring within and adjacent to the Hartwell Drainage and Levee District

	Lentic Systems	Lotic Systems							
	Pond Sand Hole	Ditches						Apple Creek	Hurricane Creek
Station No.	7	1	2	3	4	5	6	9	10
Species									
Shortnose gar								7	
Gizzard shad		7	26	42	28	10	14	12	
Carp	109	63	49	53	122		49	25	
Hornyhead chub									2
Golden shiner			<1						1
Emerald shiner									<1
Bigmouth shiner									<1
Red shiner								<1	2
Suckermouth minnow									<1
Bluntnose minnow									<1
Carp fry								<1	
Quillback								<1	
Bigmouth buffalo									<1
Black bullhead			3						
Brown bullhead					8				1
Sunfish fry				<1	<1	<1			
Green sunfish				9		6	2	<1	
Warmouth						1	1		
Bluegill	11	6	5	<1	10	13	24	1	<1
Spotted bass							1		6
Largemouth bass	47		37	46		39			
White crappie		5			35	2	2		
Freshwater Drum								<1	
Totals	167	81	120	95	203	71	93	45	12

1.5 lb. in weight over all sampling stations. Per acre biomass estimate for bass averaged 41 lb./acre in the ditches where they occurred and 20.3 lb./acre over all six drainage ditches. White crappie were found in four of the six ditches. At Station 4, white crappie were abundant. Biomass for white crappie at this station was 35 lb./acre. Bluegill sunfish were captured at each of the six drainage ditches and were most abundant at Station 6. Bluegill averaged 10 lb./acre over the six drainage ditch locations. Other species found in the drainage ditches were green sunfish, warmouth, spotted bass, black bullhead, brown bullhead, and golden shiner (Table 6). The drainage ditches mainly support wide ranging species, tolerant of fluctuating and extreme environmental conditions typical of this habitat.

The two flanking creeks, Apple Creek and Hurricane Creek, differed markedly in the distribution of fish species. These differences reflect the difference in physical habitat between the two creeks.

Apple Creek is sluggish, highly turbid (140 FTU), with steep sloping cut banks and with silt/clay bottom sediments. Dissolved oxygen levels were moderate (5.5 ppm). Fishes collected in order of decreasing biomass/acre were carp, gizzard shad, shortnose gar, bluegill, green sunfish, quillback, and red shiner (Table 7). Several hundred carp fry (18-25 mm total length) were collected in seine hauls but were not included in the quantitative analysis. The large number of carp fry indicated successful recruitment of this species. Apple Creek can be considered big river habitat and the species found there were wide ranging and big river fishes.

Hurricane Creek is narrower with swifter flow and higher dissolved oxygen (8.2 ppm). It is moderately turbid, with moderately sloping banks and with a greater diversity of bottom sediments including silt, sand, course sand, gravel, and small cobble. The fish assemblage in this area typifies a higher gradient stream. Dominant fishes in decreasing order of abundance occurring in this area were red shiner, bigmouth shiner, bluntnose minnow, hornyhead chub, brown bullhead, spotted bass, suckermouth minnow, golden shiner, emerald shiner, and bluegill (Table 6). The upper reaches of Hurricane Creek typify a prairie stream as do the assemblage of fishes within this habitat.

Sand Hole Pond is a small spring fed pond (3 acres). Only three species of fish were collected in this area and the Shannon-Wiener diversity index was the lowest (1.03) of all sampling stations. A total of 5 carp, 9 bluegill, and 2 largemouth bass were collected for a combined weight of 12.6 lb. The per acre biomass estimates for these fishes were 217, 47, and 11 lb./acre, respectively, for a total of 274 lb./acre. This was the highest of all the sampling sites and is likely due to the capture of a single large 7 lb. carp.

Brushy Lake Swamp was not sampled for fishes because of inaccessability. The dominant fishes known to occur in the swamp are stunted bluegills, mud minnows, and bowfin (Powell, personal communication). Brushy Lake Swamp does not support a recreational fishery.

Recent fishery investigations have been conducted within nearby Drainage and Levee Districts (Eldred and Spanky-Thomerson 1977; Nutwood-Axtell 1981). These districts are similar in habitat to the Hartwell District and the fish assemblages found within Eldred and Spanky and Nutwood relect those of the present study. A total of 33 species are known to exist among the three

districts. Ten species are common to all three districts (see Appendix Table A.1). There were some differences in species distribution among the three districts. Four species collected from the Nutwood District and 11 species collected from the Eldred and Spanky District were not found in the Hartwell District. Conversely, 6 species found in the Hartwell District were not reported for Eldred and Spanky and 10 species found here were not reported for Nutwood.

These differences in species occurrence can reflect differences in fish habitat, differences in level of sampling effort, and/or differences in sampling gears and efficiency. Likely, a combination of these factors are the cause of species occurrence differences among the three districts.

The aquatic habitats within the Hartwell District, with the exception of Brushy Lake Swamp, support a recreational fishery. Although the major ditches, bordering creeks, and Sand Hole Pond are on privately owned land, access to the habitats is not restricted in most cases. Fishing occurs along ditch and stream banks, from bridges, and from small boats that are lowered from steep banks. Overall, fishing pressure is moderate to heavy within the district. It is estimated that between 20 to 40 people from nearby towns fish the district weekly (Powell, personal communication). Most people fish for carp and bullheads, although some of the major ditches and Sand Hole Pond are also fished for largemouth bass and white crappie. The field collections at Hartwell have verified that adequate bass and crappie populations exist in certain areas of the district to sustain a game fishery.

No species listed as threatened or endangered in the State of Illinois were collected within the Hartwell District.

3.4.2 Benthic Macroinvertebrates

Five replicate ponar benthic samples and one qualitative sample were collected at each of the 10 locations to evaluate the distribution of benthic macroinvertebrates within the various aquatic habitats. Forty-three species of benthic dwelling organisms were identified within the district. The bottom fauna was dominated by aquatic oligochaetes, namely tubificid and naid worms, and chironomids (midges). Over all sampling locations, aquatic oligochaetes made up 64.5% of the total fauna and densities averaged 800/sq.m. Chironomid lavae made up 19.2% of the total and averaged 250 organisms/sq.m. Diversity in the aquatic habitats is low. Shannon-Wiener diversity indices averaged 1.15 and the average number of species found per sampling location within the district averaged 11 (Table 8). Comprehensive species lists and quantitative information on individual species and sampling locations are presented in Appendix B.

The greatest densities of aquatic oligochaetes were found in the ditches. There they averaged 1063 organisms/sq.m. and made up about 74% of the total bottom fauna. The most abundant worms were *Limnodrilus* spp., *L. spiralis*, and *L. cervix*. Each of these species are considered tolerant of moderate to heavy organic pollution (Weber 1973). They are substrate feeders and are found in silty, muddy sediments of sluggish and turbid waters, characteristic of drainage ditches. *Dero* sp., a naid, and *Lumbriculus* sp. were also collected in the ditches.

Table 8. Summary of major groups of benthic macroinvertebrates collected in and adjacent to the Hartwell District.

	Lentic Systems		Lotic Systems							
	Swamp Brushy Lake	Pond Sand Hole	Ditches						Apple Creek	Hurricane Creek
Station No.	8	7	1	2	3	4	5	6	9	10
Taxon										
Aquatic Oligochaetes										
No./sq.m.	270	602	1176	1190	1218	1017	650	1128	664	48
% comp.	45.9	18.8	85.4	67.5	86.3	85.5	63.5	57.0	71.6	63.6
Chironomids										
No./sq.m.	284	145	145	547	166	90	318	706	111	0
% comp.	48.2	4.5	10.6	31.0	11.8	7.6	31.1	35.7	11.9	0
Chaoborus sp.										
No./sq.m.	0	2111	35	14	21	0	28	104	0	0
% comp.	0	65.7	2.5	.8	1.5	0	2.7	5.2	0	0
Total Density										
No./sq.m.	588	3211	1377	1765	1412	1190	1024	1979	92[illegible]	[illegible]
Total Species (ponar)	12	11	12	10	9	11	9	14	15	
Total Species[3]	12	12	12	11	9	13	10	14	16	NS[2]
Shannon-Wiener Index[1]	1.86	.91	1.0	.97	.86	.96	1.13	1.39	1.32	1.10

(1) Based on quantitive ponar samples only

(2) NS = not sampled qualitatively

(3) Total = species found in quantitative samples + additions from qualitative samples

Chironomid lavae made up 21.3% of the ditch fauna and averaged 328 organisms/sq.m. The most abundant midges were Chironomus sp. and Cryptochironomus sp. Both of these midges are considered facultative in their tolerance to pollution. Other midges included Glyptotendipes sp., Parachironomus sp., and Procladius sp.

The bottom fauna in Apple Creek was similar to that found in the ditches. The dominant organisms were tubificid worms and chironomid larvae. The dominant worms were Limnodrilus sp., L. cervix, nd L. spiralis. The mot abundant chironomid larvae were Polypedilum sp., Cryptochironmus sp., Procladius sp., and Ablabesmyia sp. One taxon of mayfly, Stenacron sp., was found in this habitat. Members of this genera are considered intolerant of high levels of organic pollution. Two genera of caddisflies, Cheumatopsyche sp. and Hydropsyche sp., were taken from Apple Creek. No mayflies or caddisflies were collected from the ditches. Species diversity was higher in Apple Creek than in the ditches (Table 8). A total of 16 species were collected from this area.

Only four taxa were collected from Hurricane Creek. These were Limnodrilus sp. (35/sq.m.), Hyalella azteca (7/sq.m.), Stenonema sp. (7/sq.m.), and Cheumatopsyche sp. (14/sq.m.). The bottom sediments in this area were mainly course sand and gravel. There was evidence of recent scouring of the bottom from recent heavy rains and high stream velocities. The bottom fauna may have been partially removed or disturbed at the time of sampling.

The bottom fauna in Sand Hole Pond was dominated by Chaoborus sp., a dipteran. This organism made up 65.7% of the fauna and densities averaged about 2,000 organisms/sq.m. Chaoborus is considered facultative to intolerant of organic pollution. Other dominant organisms included aquatic oligochaetes (18.8%) and chironomid lavae (4.5%). Total density of 3,211 organisms/sq.m. was the highest recorded density within the district. Species diversity was low at 0.91 (Table 8).

The most abundant bottom fauna found in Brushy Lake Swamp were chironomids (284/sq.m.) and aquatic oligochaetes (270/sq.m.) The dominant midges were Chironomus sp. (17.6%), Kiefferulus sp. (9.4%), Polypedilum sp. (8.2%), Glyptotendipes sp. (1.2%), and Procladius sp. (1.2%). The most abundant aquatic oligochaetes were of the family Naididae. These were Dero sp., Dero furcatus, and Pristina schmiederi. The total bottom faunal density, 588 organisms/sq.m., was lower than all other sites except Hurricane Creek. Twelve taxa were found in the swamp and the Shannon-Wiener index was 1.86 (Table 8).

Qualitative smapling of benthic macroinvertebrates by hand collections reflected the quantitative samples. Midges and tubificid worms were the dominant organisms. Additional species were encountered at only four of the ten sampling locations (Table 8).

The bentnic fauna occurring in the Hartwell District reflects that found in two nearby districts, Eldred and Spanky and Nutwood. In all districts, the dominant organisms were aquatic oligochaetes of the families Tubificidae and Naididae, and chironomid larvae. Species diversity is somewhat lower in the Hartwell District. The average number of taxa was 11, compared to 22 reported by Axtell (1981) for Nutwood and 22 reported by Thomerson (1977). Total

density of macroinvertebrates was higher in the Hartwell District. The average density was 1,355 organisms/sq.m. Axtell (1981) reported mean densities in the range of 60-100 organisms/sq.m. for the Nutwood District. Thomerson (1977) reported densities of 400 organisms/sq.m.

3.4.3 Zooplankton

Thirty-four species of zooplankton were identified within the Hartwell District. Over all sampling stations, the average zooplankton density was 236 organisms/l. Rotifers dominated the zooplankton (55%-99.8% of the total count) (Table 9). Polyarthra spp. was the most abundant rotifer and it was found in all habitats, standing water, ditches, and bordering creeks. Other rotifers common to all habitats were Brachionus, Synchaeta, Trichocerca, Keratella cochlearis, and Filinia longiseta (Appendix Table C.1). These species are considered widely distributed and common. Copepods and cladocerans were less abundant. Copepods were limited mainly to Nauplii. Cyclopoid copepodid types and Eucyclops agilis were found in restricted areas. Cladoceran zooplankton were represented by four species (Appendix C.1).

Twenty-three taxa of zooplankton were found in the drainage ditches (Appendix C.1,2). Rotifers dominated the collection. Polyartha spp. was abundant at Stations 1 (270/1) and 5 (80/1). At all other ditch stations densities for this rotifer were less than 7 organisms/l. Brachionus calyciflorus was abundant only at Station 5 (257/1). It was not found at Stations 2, 3, 4, and 6 and only one organism was collected at Station 1. Synchaeta spp. was abundant only at Station 5 (83/1). Copepods and cladocerans were present in the ditches but not abundant. Both groups averaged 8 organisms/l (Table 9) (Appendix C.2).

Twelve zooplankton taxa were identified from the bordering creeks. In Apple Creek, the average density was 32 organisms/l. Rotifers were the dominant group comprising 88.2% of the total density. Keratella cochlearis (16/1) was the most abundant rotifer. Copepods were represented by Nauplii. Only one species of Cladocera, Alona spp., was collected in Apple Creek. In Hurricane Creek the average density was 22/1. Nauplii copepods and Keratella cochlearis were the most abundant organisms (Appendix C.3).

The lentic habitats were represented by 24 zooplankton taxa. Zooplankton densities were greater in the standing water habitats than in the drainage ditches or the bordering creeks. The average density for the two lentic habitats was 664 organisms/l (Table 9). In Sand Hole Pond 13 taxa were present. Rotifers were very abundant (1,032/l) and comprised over 99% of the community. Keratella cochlearis (719/l) was the dominant rotifer in this habitat. Polyarthra spp. and Synchaeta spp. were also abundant. In Brushy Lake Swamp, 20 species were collected and diversity was higher than in Sand Hole Pond (Table 9). Planktonic density (293/l) was less than the density observed in the pond. Rotifers were the dominant group. Trochosphaera solstitialis (49/l) was the most abundant species.

All of the zooplankters collected are considered widely distributed and common species. At several of the drainage ditches and in the bordering creeks zooplankton densities were fairly low suggesting that environmental conditions may have been limiting in these areas. Heavy rains, high stream flows, and high silt loading that occurred in mid-July may have limited zoo-

Table 9. Summary of major groups of zooplankton collected in and adjacent to the Hartwell District

	Lentic Systems		Lotic Systems							
	Swamp Brushy Lake	Pond Sand Hole	Ditches						Apple Creek	Hurricane Creek
Station No.	8	7	1	2	3	4	5	6	9	10
Taxonomic Group										
Rotifers										
No./l	213	1032	319	19	22	13	506	12	28	12
% comp.	72.7	99.8	87.2	56.7	57.1	80.0	97.6	84.6	86.2	55.0
Copepods										
No./l	72	2	11	9	17	—	12	2	3	9
% comp.	24.6	.2	3.0	26.7	42.9	—	2.4	15.4	10.3	40.0
Cladocerans										
No./l	4	—	36	6	—	3	—	—	1	—
% comp.	1.5	—	9.7	16.7	—	20.0	—	—	3.4	—
Total Density										
No./l	293	1034	366	33	39	17	518	14	32	22
Total	20	13	14	10	8	9	11	10	8	9
Shannon-Wiener Index	2.50	1.00	1.11	2.04	1.62	1.90	1.50	2.25	1.63	1.84
TOTAL TAXA (all stations)	34									

plankton abundance by direct dilution. Also, low secchi readings and high turbidity measurements at the two bordering creeks and five of the six ditches indicated highly turbid water conditons for these habitats. High turbidity can limit production of rotifers and other zooplankton species.

3.4.4 Phytoplankton

Sixty-nine species of phytoplankton were collected within the Hartwell District. The average density over all sampling stations was 3,966 organisms/ml. Chlorophyta (green) and Cyanophyta (bluegreen) algae dominated the collections. Bacillariophyta (diatoms) were abundant in restricted areas. The most abundant taxa were considered good indicators of high eutrophic conditions. Complete species listings are presented in Appendix D.

In the ditches, 46 taxa were collected and the average density was 4,054/ml. Green algae made up about 50% of the total density (Table 10). Ankistrodesmus falcatus, Chlamydomonas, Dictosphaerium pulchellum and Micratinum pusillum were the dominant green algal species. These species are all highly tolerant of organic pollution (Palmer 1977). Cryptomonas erosa, a cryptophyte, had the highest density for any one species (935/ml). This organism is generally found in highly eutrophic waters. The diatoms were represented by Cyclotella and Nitschia. Euglena was abundant in two of the six ditches (Appendix D.1).

The two bordering creeks differed markedly in abundance and distribution of phytoplankton. In Apple Creek, 28 species were identified and the density was 1,218/ml. Oscillatoria, a bluegreen, predominated at this site (473/ml). Euglena (134/ml), Cryptomonas (128/ml), and Trachelomonas (108/ml) were also abundant. These are all strong indicators of organically enriched waters (Appendix D.2).

A depleted phytoplankton population was found in Hurricane Creek. Only six taxa were present and the density was low (48/ml). Oscillartoria (28/ml) was the most abundant species (Appendix D.2). At the time of sampling, flow of Hurricane was significant (>1.5 ft/sec) from recent heavy rains and may explain the limited numbers of phytoplankton present in this habitat.

Differences in phytoplankton abundance were noted between the two lentic habitats. In Sand Hole Pond, 35 species were present and the density (13,787/ml) was the highest of all sampling stations (Table 10). Anacystis (5,913/ml), a bluegreen, was the dominant organism. Cyclotella stelligera (2,498/ml), a diatom, and Scenedesmus bijuga v. alterans (943/ml), a green algae, were also abundant. These taxa are also considered tolerant to high organic pollution. In contrast, species diversity and density were low in Brushy Lake Swamp. Only 13 taxa were collected and the total density was 285 organisms/ml. Euglena, Phacus tortus, and Trachelomonus sp. were the dominant organisms (Appendix D.3). The surface waters of Brushy Lake Swamp were thick with duck weed and other aquatic macrophytes. This condition may have limited light penetration to the subsurface waters and may explain the low numbers of phytoplankton present in this habitat.

Overall, phytoplankton production in the district appeared to be high. Most of the species present are considered tolerant of high nutrient levels. Altnough most sampling sites were moderately to highly turbid (a known

Table 10. Summary of major groups of phytoplankton collected in and adjacent to the Hartwell Drainage District

		Lentic Systems		Lotic Systems							
		Swamp Brushy Creek	Pond Sand Hole	Ditches						Apple Creek	Hurricane Creek
Station No.		8	7	1	2	3	4	5	6	9	10
Taxonomic Group											
Chlorophyta	No./ml	3	3364	489	231	3588	77	4669	4098	206	8
	% comp.	0.9	24.4	17.4	65.2	80.4	31.6	91.6	36.1	16.9	15.9
Bacilliariophyta	No./ml	23	2752	71	36	347	—	163	2772	113	3
	% comp.	8.1	20.0	2.5	10.1	7.8	—	3.2	24.2	9.3	5.3
Cyanophyta	No./ml	49	6320	10	5	204	3	41	295	493	28
	% comp.	17.1	45.8	0.4	1.4	4.6	1.1	0.8	2.6	40.5	57.9
Cryptophyta	No./ml	5	714	1998	62	306	146	71	3155	144	8
	% comp.	1.8	5.2	71.0	17.4	6.8	60.0	1.4	27.8	11.8	15.8
Chrysophyta	No./ml	—	102	—	—	—	5	31	206	10	—
	% comp.	—	0.7	—	—	—	2.1	0.6	1.8	0.8	—
Euglenophyta	No./ml	206	408	245	21	20	8	122	796	247	3
	% comp.	72.1	3.0	8.7	5.8	0.5	3.2	2.4	7.0	20.3	5.3
Pyrrhophyta	No./ml	—	102	—	—	—	5	—	—	5	—
	% comp.	—	0.7	—	—	—	2.1	—	—	0.4	—
Total Density	No./ml	284	13787	2814	355	4465	244	5097	11352	1218	49
Total Taxa		13	35	13	8	17	11	23	32	28	6
Shannon-Wiener Index		1.86	2.16	1.17	1.22	1.9	1.34	2.06	2.41	2.28	1.31

limiting factor) (Table 5), probable high nitrogen and phosphorus loading to the system from agricultural drainage present favorable conditions for phytoplankton growth. Kulfinski (1977) reported that phytoplankton densities ranged from 175 to 13,000/ml at the Eldred and Spanky District. These are consistent with the densities found in this study. He also found a similar assemblage of eutrophic indicator species. Axtell (1981) reported relatively low numbers of phytoplankton organisms in the Mutwood District. Only 12 species were identified and densities averaged only 600 organisms/ml.

4.0. SUMMARY AND RECOMMENDATIONS

Land in the Hartwell District is used primarily for agricultural practices. The major aquatic habitats in the district are large and small ditches used to drain excess water from croplands. Secondly, the ditches provide recreational fishing for district residents and people from nearby communities. Most of the ditches support rough fishes, and in several areas largemouth bass and/or white crappie are abundant enough to support a modest game fishery. A 3 acre pond is also used for bass and carp fishing.

The ditches take on heavy loads of silt from cropland erosion and are dredged (by draglining) on a regular basis. Dredge spoil is put back into the fields. The bottom fauna is limited to aquatic oligochaetes and chironomid larvae. The plankton species are indicative of high nutrient loading and organic pollution. The aesthetic value of the ditches could be improved by:

1. Maintaining vegetation along side of the ditches by not plowing with dredge spoil

2. Dredge various reaches of ditches to different depths to provide a greater variety of fish habitats.

An 87 acre shrub swamp located in the southwest corner of the district does not support recreational fishing. It is, however, considered a valuable wetlands resource for waterfowl and wildlife. For several years the privately owned swamp has been leased to a local duck club for hunting rights. The current owner is considering draining the swamp for agricultural purposes. Some members of the community are concerned and would like the swamp to remain intact for aesthetic value. An opportunity to preserve the swamp exists and the feasibility of either local or state acquisition of the land should be examined.

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APPENDIX A

FISH

Appendix Table A.1. Composite species list of fish known to occur in the Hartwell Drainage and Levee District through recent field collections

Species	Eldred and Spankey Thomerson (1977)	Nutwood Axtell (1981)	Hartwell (Present study)
Shortnose gar	X		X
Bowfin	X		
Gizzard shad	X	X	X
Grass pickeral	X		
Carp	X	X	X
Goldfish	X		
Golden shiner	X	X	X
Hornyhead chub			X
Emerald shiner	X	X	X
Bigmouth shiner			X
Red shiner	X		X
Suckermouth minnow			X
Bluntnose minnow			X
Fathead minnow	X		
Bigmouth buffalo			X
River carpsucker	X		
Quillback	X		X
Black bullhead	X	X	X
Brown bullhead	X		X
Channel catfish	X		
Blackstriped topminnow	X	X	
Mosquito fish	X		
White bass	X		
Spotted bass			X
Largemouth bass	X	X	X
Black crappie	X	X	
White crappie	X	X	X
Warmouth	X	X	X
Green sunfish	X	X	X
Orangespotted sunfish	X	X	
Bluegill	X	X	X
Brood silversides		X	
Freshwater drum	X	X	X
Total Species	26	15	21
Total Species (all Districts)	33		

Appendix A.2. Summary of Fish collected (all sampling stations combined) within the Hartwell District and bordering creeks during a Joint Field Reconnaisance/Biological Survey conducted between 24 July and 11 August 1981

SPECIES LIST	TOTAL NO	NO/ ACRE	LB/ ACRE	PCT COMP	WEIGHT (GM) MIN	WEIGHT (GM) MAX	WEIGHT (GM) MEAN	LENGTH (CM) MIN	LENGTH (CM) MAX	LENGTH (CM) MEAN
SHORTNOSE GAR	1	2	1	.3			220.			40.5
GIZZARD SHAD	79	191	15	25.8	1.	160.	36.	5.	26.	14.8
CARP	26	63	65	8.5	1.	3000.	468.	4.	61.	31.3
HORNYHEAD CHUB	4	10		1.3	4.	6.	5.	7.	7.	6.7
GOLDEN SHINER	2	5		.7	10.	10.	10.	10.	10.	9.6
EMERALD SHINER	1	2		.3			1.			4.2
BIGMOUTH SHINER	7	17		2.3			1.			5.0
RED SHINER	12	29		3.9	1.	2.	2.	4.	5.	4.7
SUCKERMOUTH MINNOW	1	2		.3			1.			3.0
BLUNTNOSE MINNOW	5	12		1.6	1.	1.	1.	4.	5.	3.8
CARP FRY	50	121		16.3			.			2.5
QUILLBACK	1	2		.3			8.			8.3
BIGMOUTH BUFFALO	1	2		.3			2.			5.8
BLACK BULLHEAD	1	2		.3			60.			15.6
BROWN BULLHEAD	4	10	1	1.3	1.	150.	40.	4.	21.	9.0
SUNFISH	5	12		1.6	.	1.	.	3.	4.	3.3
GREEN SUNFISH	7	17	2	2.3	1.	160.	48.	3.	21.	10.3
WARMOUTH	3	7		1.0	10.	30.	17.	9.	11.	9.8
BLUEGILL	70	169	8	22.9	1.	120.	22.	3.	18.	9.9
SPOTTED BASS	4	10	2	1.3	12.	220.	76.	9.	28.	16.4
LARGEMOUTH BASS	5	12	17	1.6	18.	820.	636.	12.	44.	33.4
WHITE CRAPPIE	16	39	4	5.2	18.	232.	53.	11.	27.	15.3
FRESHWATER DRUM	1	2		.3			4.			5.3
TOTALS	306	741				TOTAL WEIGHT (KG)				21.80
TOTAL SPECIES		23				KG/ACRE				52.75
SHANNON-WIENER INDEX		2.23				TOTAL POUNDS/ACRE				116

SAMPLING EFFORT
220V AC ELECTROFISHING - 8 HOURS
SEINE - 8 HAULS
18000 SQUARE FEET

PHYSICAL PARAMETERS

	MIN	MAX	MEAN
TEMPERATURE (DEG C)	20.5	26.0	22.5
DISSOLVED OXYGEN (PPM)	3.0	8.2	5.5

APPENDIX TABLE A. 3. SUMMARY OF FISHERY SURVEY - STATION 1

SPECIES LIST	TOTAL NO	NO/ ACRE	LB/ ACRE	PCT COMP	WEIGHT (GM) MIN	WEIGHT (GM) MAX	WEIGHT (GM) MEAN	LENGTH (CM) MIN	LENGTH (CM) MAX	LENGTH (CM) MEAN
GIZZARD SHAD	6	105	7	35.3	22.	58.	32.	14.	19.	15.4
CARP	4	70	63	23.5	300.	720.	410.	29.	41.	32.9
BLUEGILL	4	70	6	23.5	2.	80.	38.	5.	14.	9.4
WHITE CRAPPIE	3	52	5	17.6	36.	44.	41.	14.	17.	15.4

TOTALS	17	296	
TOTAL SPECIES		4	
SHANNON-WIENER INDEX		1.35	
TOTAL WEIGHT (KG)			2.10
KG/ACRE			36.56
TOTAL POUNDS/ACRE			81

SAMPLING EFFORT

220V AC ELECTROFISHING - 60 MINUTES
1/4 INCH SEINING - 5 HAULS
2500 SQUARE FEET

PHYSICAL PARAMETERS

	MIN	MAX	MEAN
TEMPERATURE (DEG C)	-	-	23.0
DISSOLVED OXYGEN (PPM)	-	-	3.6

APPENDIX TABLE A.4. SUMMARY OF FISHERY SURVEY - STATION 2

SPECIES LIST	TOTAL NO	NO/ ACRE	LB/ ACRE	PCT COMP	WEIGHT (GM) MIN	WEIGHT (GM) MAX	WEIGHT (GM) MEAN	LENGTH (CM) MIN	LENGTH (CM) MAX	LENGTH (CM) MEAN
GIZZARD SHAD	15	327	26	51.7	20.	110.	36.	12.	23.	15.7
CARP	3	65	49	10.3	300.	380.	343.	30.	35.	32.3
GOLDEN SHINER	1	22		3.4			10.			9.5
BLACK BULLHEAD	1	22	3	3.4			60.			15.8
BLUEGILL	8	174	5	27.6	6.	30.	14.	9.	16.	10.8
LARGEMOUTH BASS	1	22	37	3.4			780.			35.0
TOTALS	29	632								
TOTAL SPECIES		6								
SHANNON-WIENER INDEX		1.28								

TOTAL WEIGHT (KG)	2.54
KG/ACRE	55.23
TOTAL POUNDS/ACRE	122

SAMPLING EFFORT

220V AC ELECTROFISHING - 60 MINUTES
1/4 INCH SEINE - 5 HAULS
2000 SQUARE FEET

PHYSICAL PARAMETERS

	MIN	MAX	MEAN
TEMPERATURE (DEG C)	-	-	22.0
DISSOLVED OXYGEN (PPM)	-	-	3.3

APPENDIX TABLE A. 5. SUMMARY OF FISHERY SURVEY - STATION 3

SPECIES LIST	TOTAL NO	NO/ ACRE	LB/ ACRE	PCT COMP	WEIGHT (GM) MIN	WEIGHT (GM) MAX	WEIGHT (GM) MEAN	LENGTH (CM) MIN	LENGTH (CM) MAX	LENGTH (CM) MEAN
GIZZARD SHAD	20	498	42	66.7	2.	78.	38.	6.	19.	15.1
CARP	3	75	53	10.0	198.	420.	320.	26.	34.	30.1
SUNFISH	2	50		6.7	1.	1.	1.	4.	4.	3.9
GREEN SUNFISH	1	25	9	3.3			160.			20.5
BLUEGILL	2	50	3	6.7	20.	32.	26.	11.	12.	11.1
LARGEMOUTH BASS	2	50	46	6.7	18.	820.	419.	12.	44.	27.8

TOTALS	30	747	
TOTAL SPECIES		6	
SHANNON-WIENER INDEX		1.16	
TOTAL WEIGHT (KG)			2.78
KG/ACRE			69.10
TOTAL POUNDS/ACRE			152

SAMPLING EFFORT

220V AC ELECTROFISHING - 60 MINUTES
1750 SQUARE FEET

PHYSICAL PARAMETERS

	MIN	MAX	MEAN
TEMPERATURE (DEG C)	-	-	22.0
DISSOLVED OXYGEN (PPM)	-	-	3.0

APPENDIX TABLE A. 6. SUMMARY OF FISHERY SURVEY - STATION 4

SPECIES LIST	TOTAL NO	NO/ ACRE	LB/ ACRE	PCT COMP	WEIGHT (GM) MIN	WEIGHT (GM) MAX	WEIGHT (GM) MEAN	LENGTH (CM) MIN	LENGTH (CM) MAX	LENGTH (CM) MEAN
GIZZARD SHAD	14	348	28	34.1	1.	50.	36.	5.	18.	14.3
CARP	5	124	122	12.2	192.	760.	443.	24.	42.	31.0
BROWN BULLHEAD	1	25	8	2.4			150.			21.0
SUNFISH	2	50		4.9	.	1.	.	3.	3.	2.9
BLUEGILL	8	199	10	19.5	4.	42.	23.	6.	13.	9.8
WHITE CRAPPIE	11	274	35	26.8	18.	232.	59.	11.	27.	15.3

TOTALS	41	1021	
TOTAL SPECIES		6	
SHANNON-WIENER INDEX		1.53	
TOTAL WEIGHT (KG)			3.70
KG/ACRE			92.18
TOTAL POUNDS/ACRE			203

SAMPLING EFFORT

220V AC ELECTROFISHING - 60 MINUTES
1/4 INCH SEINE - 10 HAULS
1750 SQUARE FEET

PHYSICAL PARAMETERS

	MIN	MAX	MEAN
TEMPERATURE (DEG C)	-	-	22.0
DISSOLVED OXYGEN (PPM)	-	-	5.0

WAPORA

APPENDIX TABLE A. 7. SUMMARY OF FISHERY SURVEY - STATION 5

SPECIES LIST	TOTAL NO	NO/ ACRE	LB/ ACRE	PCT COMP	WEIGHT (GM) MIN	MAX	MEAN	LENGTH (CM) MIN	MAX	MEAN
GIZZARD SHAD	6	131	10	22.2	20.	58.	35.	13.	19.	16.0
SUNFISH	1	22		3.7			1.			2.8
GREEN SUNFISH	2	44	6	7.4	30.	100.	65.	12.	16.	14.2
WARMOUTH	1	22	1	3.7			30.			11.2
BLUEGILL	15	327	13	55.6	3.	40.	19.	6.	14.	10.2
LARGEMOUTH BASS	1	22	39	3.7			820.			38.2
WHITE CRAPPIE	1	22	2	3.7			35.			15.0

TOTALS	27	588	TOTAL WEIGHT (KG) 1.49
TOTAL SPECIES		7	KG/ACRE 32.55
SHANNON-WIENER INDEX		1.34	TOTAL POUNDS/ACRE 72

SAMPLING EFFORT

220V AC ELECTROFISHING - 60 MINUTES
2000 SQUARE FEET

PHYSICAL PARAMETERS

	MIN	MAX	MEAN
TEMPERATURE (DEG C)	-	-	22.0
DISSOLVED OXYGEN (PPM)	-	-	6.4

APPENDIX TABLE A. 8. SUMMARY OF FISHERY SURVEY - STATION 6

SPECIES LIST	TOTAL NO	NO/ ACRE	LB/ ACRE	PCT COMP	WEIGHT (GM) MIN	WEIGHT (GM) MAX	WEIGHT (GM) MEAN	LENGTH (CM) MIN	LENGTH (CM) MAX	LENGTH (CM) MEAN
GIZZARD SHAD	8	174	14	22.9	30.	50.	37.	14.	16.	15.0
CARP	2	44	49	5.7	500.	525.	513.	36.	40.	37.8
GREEN SUNFISH	1	22	2	2.9			40.			12.0
WARMOUTH	2	44	1	5.7	10.	10.	10.	9.	10.	9.1
BLUEGILL	20	436	24	57.1	3.	120.	25.	6.	18.	10.3
SPOTTED BASS	1	22	1	2.9			20.			13.2
WHITE CRAPPIE	1	22	2	2.9			40.			15.2

TOTALS	35	762	
TOTAL SPECIES		7	
SHANNON-WIENER INDEX		1.29	
TOTAL WEIGHT (KG)			19.1
KG/ACRE			42.10
TOTAL POUNDS/ACRE			93

SAMPLING EFFORT

220V AC ELECTROFISHING - 60 MINUTES
2000 SQUARE FEET

PHYSICAL PARAMETERS

	MIN	MAX	MEAN
TEMPERATURE (DEG C)	-	-	20.5
DISSOLVED OXYGEN (PPM)	-	-	6.7

WAPORA

APPENDIX TABLE A. 9. SUMMARY OF FISHERY SURVEY - STATION 7

SPECIES LIST	TOTAL NO	NO/ ACRE	LB/ ACRE	PCT COMP	WEIGHT (GM) MIN	MAX	MEAN	LENGTH (CM) MIN	MAX	MEAN
CARP	5	109	217	31.3	300.	3000.	904.	30.	61.	37.7
BLUEGILL	9	196	11	56.3	1.	80.	25.	5.	17.	10.2
SPOTTED BASS	1	22	11	6.3			220.			28.0
LARGEMOUTH BASS	1	22	36	6.3			740.			38.0
TOTALS	16	348								
TOTAL SPECIES		4								
SHANNON-WIENER INDEX		1.03								

TOTAL WEIGHT (KG)	5.70
KG/ACRE	124.21
TOTAL POUNDS/ACRE	274

SAMPLING EFFORT

220V AC ELECTROFISHING - 60 MINUTES
2000 SQUARE FEET

PHYSICAL PARAMETERS

	MIN	MAX	MEAN
TEMPERATURE (DEG C)	-	-	26.0
DISSOLVED OXYGEN (PPM)	-	-	7.6

APPENDIX TABLE A.10. SUMMARY OF FISHERY SURVEY - STATION 9

SPECIES LIST	TOTAL NO	NO/ ACRE	LB/ ACRE	PCT COMP	WEIGHT (GM) MIN	WEIGHT (GM) MAX	WEIGHT (GM) MEAN	LENGTH (CM) MIN	LENGTH (CM) MAX	LENGTH (CM) MEAN
SHORTNOSE GAR	1	15	7	1.3			220.			40.5
GIZZARD SHAD	10	145	12	13.3	4.	160.	37.	7.	26.	12.3
CARP	4	58	25	5.3	1.	400.	1 3.	4.	30.	19.0
RED SHINER	2	29		2.7	1.	1.	1.	4.	4.	4.0
CARP FRY	50	726		66.7			.			2.5
QUILLBACK	1	15		1.3			8.			8.3
GREEN SUNFISH	3	44		4.0	1.	2.	1.	3.	5.	3.7
BLUEGILL	3	44	1	4.0	1.	25.	9.	3.	12.	6.1
FRESHWATER DRUM	1	15		1.3			4.			5.3
TOTALS	75	1089								
TOTAL SPECIES		9								
SHANNON-WIENER INDEX		1.22								

TOTAL WEIGHT (KG)	1.42
KG/ACRE	20.62
TOTAL POUNDS/ACRE	45

SAMPLING EFFORT

220V AC ELECTROFISHING - 60 MINUTES
1/4 INCH SEINE - 10 HAULS
3000 SQUARE FEET

PHYSICAL PARAMETERS

	MIN	MAX	MEAN
TEMPERATURE (DEG C)	-	-	23.0
DISSOLVED OXYGEN (PPM)	-	-	5.5

APPENDIX TABLE A.11. SUMMARY OF FISHERY SURVEY - STATION 10

SPECIES LIST	TOTAL NO	NO/ ACRE	LB/ ACRE	PCT COMP	WEIGHT (GM) MIN	WEIGHT (GM) MAX	WEIGHT (GM) MEAN	LENGTH (CM) MIN	LENGTH (CM) MAX	LENGTH (CM) MEAN
HORNYHEAD CHUB	4	174	2	11.1	4.	6.	5.	7.	7.	6.7
GOLDEN SHINER	1	44	1	2.8			10.			9.6
EMERALD SHINER	1	44		2.8			1.			4.2
BIGMOUTH SHINER	7	305		19.4			1.			5.0
RED SHINER	10	436	2	27.8			2.			4.8
SUCKERMOUTH MINNOW	1	44		2.8			1.			3.0
BLUNTNOSE MINNOW	5	218		13.9	1.	1.	1.	4.	5.	3.8
BIGMOUTH BUFFALO	1	44		2.8			2.			5.8
BROWN BULLHEAD	3	131	1	8.3	1.	4.	3.	4.	6.	5.0
BLUEGILL	1	44		2.8			1.			3.2
SPOTTED BASS	2	87	6	5.6	12.	52.	32.	9.	15.	12.2

TOTALS	36	1568	TOTAL WEIGHT (KG) .13
TOTAL SPECIES		11	KG/ACRE 5.64
SHANNON-WIENER INDEX		2.06	TOTAL POUNDS/ACRE 12

SAMPLING EFFORT

1/4 SEINE - 8 HAULS
1000 SQUARE FEET

PHYSICAL PARAMETERS

	MIN	MAX	MEAN
TEMPERATURE (DEG C)	-	-	22.0
DISSOLVED OXYGEN (PPM)	-	-	8.2

APPENDIX B

BENTHIC MACROINVERTEBRATES

Appendix Table B.1. Common benthic macroinvertebrates (quantitative) identified from the Hartwell District in relative percent composition. Only organisms that made up more than 1% of the total for each station are listed

		Lentic Systems		Lotic Systems							
		Swamp Brushy Lake	Pond Sand Hole	Ditches						Apple Creek	Hurricane Creek
Station No.		8	7	1	2	3	4	5	6	9	10
Taxon	Pollution Tolerance (1)										
P-Platyhelminthes											
Unid. Turbellaria	F									3.0	
P-Nematoda											
Unid. Nematoda	F							2	1.7		
P-Annelida											
C-Hirundinea											
Unid. Hirundinea		4.7									
C-Oligochaeta											
F-Naididae											
Dero sp.	F	21.2	3.4	3.5					5.9		
Dero furcatus	F										
Pristina schmiederi											
F-Tubificidae											
Limnodrilus sp.	T	3.5	11.4	60.8	50.2	64.7	64.0	43.9	36.0	59.0	45.5
L. cervix	T		2.4	14.6	3.1	13.7	4.7	6.1	3.1	7.5	
L. hoffmeisteri	T										
L. spiralis	T			5.0	14.1	5.4	14.5	10.8	4.2	3.0	
F-Lumbriculidae											
Lumbriculus sp.	T	14.1						2.0			

Appendix Table B.1. Con't.

Taxon	Pollution Tolerance (1)	Lentic Systems: Swamp Brushy Lake	Lentic Systems: Pond Sand Hole	Lotic Systems: Ditches 1	2	3	4	5	6	Lotic Systems: Apple Creek	Lotic Systems: Hurricane Creek
Station No.		8	7							9	10
P-Arthropoda											
C-Crustacea											
O-Amphipoda											
Hyalella azteca	F										9.1
C-Insecta											
O-Coleoptera											
F-Elmidae											
Dubiraphia sp.	F		10.3								
Stenelmis sp.	F,I									3.7	
O-Diptera											
F-Chaoboridae											
Chaoborus sp.	F,I		65.7	2.5		1.5		2.7	5.2		
F-Chironomidae											
SF-Chironominae											
Chironomus sp.	F	17.6		1.0	11.0	7.8	1.2	22.3	11.2		
Cryptochironomus sp.	F	1.2		3.5	6.3		2.9		7.0	2.2	
Glyptotendipes sp.	I	1.2							2.4		
Parachironomus sp.	F								5.6		
Kiefferulus sp.	I	9.4									
Polypedilum sp.	F,I	8.2								3.7	
SF-Tanypodinae											
Procladius sp.	T,F	1.2	2.2				1.7	1.4		2.2	
Ablabesmya sp.	I									1.5	

Table B.1. Con't

		Lentic Systems		Lotic Systems							
		Swamp Brushy Lake	Pond Sand Pond	Ditches						Apple Creek	Hurricane Creek
Station No.		8	7	1	2	3	4	5	6	9	10
Taxon	Pollution Tolerance (1)										
O-Ephemeroptera											
F-Heptageneidae											
Stenonema sp.	I										9.1
Stenocron sp.	I									2.2	
O-Trichoptera											
F-Hydropsychidae											
Hydropsyche sp.	F									1.5	
Cheumatopsyche sp.	F									3.7	8.2
P-Mollusca											
C-Gastropoda											
Lymnea sp.	F						2.3				
Physa sp.	T	1.2								1.5	
Gyraulis sp.	F						1.7				
Helisoma sp.	F						1.7				
Total Density (No./sq.m.)		588	3211	1377	1765	1412	1190	1024	1979	927	76
Total Species		12	11	12	10	9	11	9	14	15	4
Shannon-Wiener Index(2)		1.86	.91	1.0	.97	.86	.96	1.13	1.39	1.32	1.10

(1) T = Tolerant to organic pollution
F = Facultative
I = Intolerant
From Weber (1973)

(2) Index computed using $\log_e$

WAPORA

Appendix B.2. Summary of benthic macroinvertebrates collected (quantitative/ ponar) at each six drainage ditches within the Hartwell District. See Figure 1 for sampling station locations.

	1		2		3		4		5		6		MEAN	
	NO/ 90 M	% COMP	NO/ 90 M	% COMP	NO/ 90 M	% COMP	NO/ 90 M	% COMP	NO/ 90 M	% COMP	NO/ 90 M	% COMP	NO/ 90 M	% COMP
P-NEMATODA	0	0.0	0	0.0	0	0.0	7	.6	21	2.0	35	1.7	10	.7
NEMATODA UNIDENTIFIABLE	0	0.0	0	0.0	0	0.0	7	.6	21	2.0	35	1.7	10	.7
P-ANNELIDA	1183	85.9	1190	67.5	1218	86.3	1017	85.5	650	63.5	1128	57.0	1065	73.0
C-HIRUDINEA	7	.5	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	1	.1
HIRUDINEA UNIDENTIFIABLE	7	.5	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	1	.1
O-GNATHOBDELLIDA														
C-OLIGOCHAETA	1176	85.4	1190	67.5	1218	86.3	1017	85.5	650	63.5	1128	57.0	1063	72.9
F-NAIDIDAE														
DERO SP	48	3.5	0	0.0	0	0.0	0	0.0	0	0.0	118	5.9	28	1.9
F-TUBIFICIDAE														
BRANCHIURA SOWERBYI	0	0.0	0	0.0	0	0.0	0	0.0	7	.7	0	0.0	1	.1
IMM. W/O CAP. CHAETAE	13	1.0	0	0.0	7	.5	28	2.3	0	0.0	152	7.7	33	2.3
LIMNODRILUS SP	837	60.8	886	50.2	913	64.7	761	64.0	458	43.9	713	36.0	760	52.1
LIMNODRILUS CERVIX	201	14.6	55	3.1	194	13.7	55	4.7	62	6.1	62	3.1	105	7.2
LIMNODRILUS HOFFMEISTERI	0	0.0	0	0.0	21	1.5	0	0.0	0	0.0	0	0.0	3	.2
LIMNODRILUS UDEKEMIANUS	0	0.0	0	0.0	7	.5	0	0.0	0	0.0	0	0.0	1	.1
LIMNODRILUS SPIRALIS	69	5.0	249	14.1	76	5.4	173	14.5	111	10.8	83	4.2	127	8.7
F-LUMBRICULIDAE														
LUMBRICULUS SP	0	0.0	0	0.0	0	0.0	0	0.0	21	2.0	0	0.0	3	.2
P-ARTHROPODA	194	14.1	574	32.5	187	13.2	90	7.6	353	34.5	810	40.9	368	25.2
C-INSECTA	194	14.1	574	32.5	187	13.2	90	7.6	353	34.5	810	40.9	368	25.2
O-DIPTERA	194	14.1	567	32.2	187	13.2	90	7.6	346	33.8	810	40.9	366	25.1
F-CERATOPOGONIDAE														
BEZZIA SP	7	.5	7	.4	0	0.0	0	0.0	0	3.0	0	0.0	2	.2
F-CHIRONOMIDAE														
CHIRONOMUS SP	35	2.5	14	.8	21	1.5	0	0.0	28	2.7	104	5.2	33	2.3
F-EPHYDRIDAE	7	.5	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	1	.1

Appendix B.2. Con't.

F-CHIRONOMIDAE	145	10.6	547	31.0	166	11.8	90	7.6	360	31.1	706	35.7	329	22.5
CHIRONOMINAE PUPAE	35	2.5	0	0.0	0	0.0	0	0.0	21	2.0	0	0.0	9	.6
SF-CHIRONOMINAE (OTH	28	2.0	194	11.0	42	2.9	7	.6	28	2.7	76	3.8	62	4.3
CRYPTOCHIRONOMUS SP	14	1.0	194	11.0	111	7.8	14	1.2	228	22.3	221	11.2	128	8.9
CRYPTOCHIRONOMUS SP	48	3.5	111	6.3	7	.5	35	2.9	0	0.0	138	7.0	57	3.9
DICROTENDIPES SP	7	.5	0	0.0	0	0.0	0	0.0	0	0.0	7	.3	2	.2
GLYPTOTENDIPES SP	0	0.0	14	.8	0	0.0	0	0.0	0	0.0	48	2.4	10	.7
PARACHIRONOMUS SP	7	.5	0	0.0	0	0.0	0	0.0	0	0.0	111	5.6	20	1.3
POLYPEDILUM SP	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	7	.3	1	.1
STENPELLINA SPP.	0	0.0	7	.4	0	0.0	0	0.0	0	0.0	0	0.0	1	.1
RHEOTANYTARSUS SP	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	7	.3	1	.1
SF-ORTHOCLADIINAE	0	0.0	0	0.0	0	0.0	7	.6	0	0.0	0	0.0	1	.1
SF-TANYPODINAE	7	.5	7	.4	7	.5	0	0.0	7	.7	14	.7	7	.5
PROCLADIUS SP	0	0.0	14	.8	0	0.0	21	1.7	14	1.4	7	.3	9	.6
O-EPHEMEROPTERA (MAYFLIES)	0	0.0	7	.4	0	0.0	0	0.0	0	0.0	0	0.0	1	.1
F-CAENIDAE														
CAENIS SP	0	0.0	7	.4	0	0.0	0	0.0	0	0.0	0	0.0	1	.1
O-[illegible]ATA (ANISOPTERA)	0	0.0	0	0.0	0	0.0	0	0.0	7	.7	0	0.0	1	.1
F-LIBELLULIDAE														
NEUROCORDULIA SP	0	0.0	0	0.0	0	0.0	0	0.0	7	.7	0	0.0	1	.1
P-MOLLUSCA	0	0.0	0	0.0	7	.5	76	6.4	0	0.0	7	.3	15	1.0
-GASTROPODA (SNAILS)	0	0.0	0	0.0	7	.5	76	6.4	0	0.0	7	.3	15	1.0
LYMNAEA SP	0	0.0	0	0.0	0	0.0	28	2.3	0	0.0	7	.3	6	.4
VIVIPARUS SP	0	0.0	0	0.0	0	0.0	7	.6	0	0.0	0	0.0	1	.1
GYRAULUS SP	0	0.0	0	0.0	7	.5	21	1.7	0	0.0	0	0.0	5	.3
HELISOMA SP	0	0.0	0	0.0	0	0.0	21	1.7	0	0.0	0	0.0	3	.2
TOTAL DENSITY	1377		1765		1412		1190		1024		1979		1458	
STANDARD ERROR OF MEAN													160.14	
RANGE OF DENSITIES	415 - 2041		450 - 3875		761 - 2837		277 - 2560		346 - 1972		1211 - 2906		277 - 3875	
TOTAL NUMBER OF TAXA	17		14		12		15		14		19		24	
NUMBER OF REPLICATES	5		5		5		5		5		5		30	
SUBSTRATE	SILT		CLAY SILT		SILT		SILT DETRITUS		CLAY SILT		DETRITUS CLAY			
DEPTH	5		5		6		7		5		6		6	

Appendix B.3. Summary of benthic macroinvertebrates collected from two lentic habitats within the Hartwell District. Sand Hole Pond (7) and Brushy Lake Swamp (8).

	7		8		MEAN	
	NO/ SQ M	% COMP	NO/ SQ M	% COMP	NO/ SQ M	% COMP
P-ANNELIDA	602	18.8	298	50.6	450	23.7
C-HIRUNDINEA	0	0.0	28	4.7	14	.7
HIRUNDINEA UNIDENTIFIABLE	0	0.0	28	4.7	14	.7
O-GNATHOBDELLIDA						
C-OLIGOCHAETA	602	18.8	270	45.9	436	23.0
F-NAIDIDAE						
DERO SP	111	3.4	125	21.2	118	6.2
DERO FURCATUS	0	0.0	28	4.7	14	.7
PRISTINA SCHMIEDERI	42	1.3	7	1.2	24	1.3
F-TUBIFICIDAE						
TUBIFICIDAE UNIDENTIFIABLE	7	.2	0	0.0	3	.2
IMM. W/O CAP. CHAETAE	0	0.0	7	1.2	3	.2
LIMNODRILUS SP	367	11.4	21	3.5	194	10.2
LIMNODRILUS CERVIX	76	2.4	0	0.0	38	2.0
F-LUMBRICULIDAE						
LUMBRICULUS SP	0	0.0	83	14.1	42	2.2
P-ARTHROPODA	2609	81.3	284	48.2	1446	76.1
C-INSECTA	2609	81.3	284	48.2	1446	76.1
O-COLEOPTERA (BEETLES)	332	10.3	0	0.0	166	8.7
F-ELMIDAE						
DUBIRAPHIA SP	332	10.3	0	0.0	166	8.7
O-DIPTERA	2256	70.3	294	48.2	1270	66.8
F-CHAOBORIDAE						
CHAOBORUS SP	2111	65.7	0	0.0	1055	55.6

Appendix B.3. Con't

F-CHIRONOMIDAE	145	4.5	284	48.2	215	11.3
SF-CHIRONOMINAE UNID	42	1.3	55	9.4	48	2.6
CHIRONOMUS SP	7	.2	104	17.6	55	2.9
CRYPTOCHIRONOMUS SP	7	.2	7	1.2	7	.4
GLYPTOTENDIPES SP	0	0.0	7	1.2	3	.2
KIEFFERULUS SP	0	0.0	55	9.4	28	1.5
POLYPEDILUM SP	0	0.0	48	8.2	24	1.3
PROCLADIUS SP	69	2.2	7	1.2	38	2.0
ANATOPENIA SP	7	.2	0	0.0	3	.2
O-ODONATA (ANISOPTERA)	7	.2	0	0.0	3	.2
F-LIBELLULIDAE						
TETRAGONEURA SP	7	.2	0	0.0	3	.2
O-TRICHOPTERA (CADDISFLIES)	14	.4	0	0.0	7	.4
F-LEPTOCERIDAE						
OECETIS SP	14	.4	0	0.0	7	.4
P-MOLLUSCA	0	0.0	7	1.2	3	.2
C-GASTROPODA (SNAILS)	0	0.0	7	1.2	3	.2
PHYSA SP	0	0.0	7	1.2	3	.2
TOTAL DENSITY	3211		588		1900	
STANDARD ERROR OF MEAN					547.64	
RANGE OF DENSITIES	1073 - 5294		346 - 934		346 - 5294	
TOTAL NUMBER OF TAXA	15		15		22	
NUMBER OF REPLICATES	5		5		10	
SUBSTRATE	SILT DETRITUS SAND		DETRITUS			
DEPTH	8		3		5	

Appendix B.4. Summary of benthic macroinvertebrates collected from the bordering creeks of the Hartwell District. Apple Creek (9) and Hurricane Creek (10)

	9		10		MEAN	
	NO/ SQ M	% COMP	NO/ SQ M	% COMP	NO/ SQ M	% COMP
P-PLATYHELMINTHES	28	3.0	0	0.0	14	2.8
TURBELLARIA UNIDENTIFIABLE	28	3.0	0	0.0	14	2.8
P-ANNELIDA	664	71.6	48	63.6	356	71.0
C-OLIGOCHAETA	664	71.6	48	63.6	356	71.0
OLIGOCHAETA UNIDENTIFIABLE	14	1.5	0	0.0	7	1.4
O-OPISTHOPORA						
F-TUBIFICIDAE						
IMM. W/O CAP. CHAETAE	0	0.0	14	18.2	7	1.4
LIMNODRILUS SP	547	59.0	35	45.5	291	57.9
LIMNODRILUS CERVIX	69	7.5	0	0.0	35	6.9
LIMNODRILUS SPIRALIS	28	3.0	0	0.0	14	2.8
F-LUMBRICULIDAE						
LUMBRICULUS SP	7	.7	0	0.0	3	.7
P-ARTHROPODA	221	23.9	28	36.4	125	24.8
C-CRUSTACEA	7	.7	7	9.1	7	1.4
O-AMPHIPODA (SCUDS)	7	.7	7	9.1	7	1.4
GAMMARUS SP	7	.7	0	0.0	3	.7
HYALELLA AZTECA	0	0.0	7	9.1	3	.7
C-INSECTA	215	23.1	21	27.3	118	23.4
O-COLEOPTERA (BEETLES)	35	3.7	0	0.0	17	3.4
F-ELMIDAE						
STENELMIS SP	35	3.7	0	0.0	17	3.4

Appendix B.4. Con't.

O-DIPTERA	111	11.9	0	0.0	55	11.0
F-CHIRONOMIDAE	111	11.9	0	0.0	55	11.0
SF-CHIRONOMINAE UNID	7	.7	0	0.0	3	.7
CRYPTOCHIRONOMUS SP	21	2.2	0	0.0	10	2.1
POLYPEDILUM SP	35	3.7	0	0.0	17	3.4
RHEOTANYTARSUS SP	7	.7	0	0.0	3	.7
SF-TANYPODINAE	7	.7	0	0.0	3	.7
PROCLADIUS SP	21	2.2	0	0.0	10	2.1
ABLABESMYIA SP	14	1.5	0	0.0	7	1.4
O-EPHEMEROPTERA (MAYFLIES)	21	2.2	7	9.1	14	2.8
F-HEPTAGENIIDAE						
STENONEMA SP	0	0.0	7	9.1	3	.7
STENACRON SP	21	2.2	0	0.0	10	2.1
O-TRICHOPTERA (CADDISFLIES)	48	5.2	14	18.2	31	6.2
F-HYDROPSYCHIDAE						
CHEUMATOPSYCHE SP	35	3.7	14	18.2	24	4.8
HYDROPSYCHE SP	14	1.5	0	0.0	7	1.4
P-MOLLUSCA	14	1.5	0	0.0	7	1.4
C-GASTROPODA (SNAILS)	14	1.5	0	0.0	7	1.4
PHYSA SP	14	1.5	0	0.0	7	1.4
TOTAL DENSITY	927		76		502	
STANDARD ERROR OF MEAN					212.80	
RANGE OF DENSITIES	0 - 1972		0 - 138		0 - 1972	
TOTAL NUMBER OF TAXA	19		5		22	
NUMBER OF REPLICATES	5		5		10	
SUBSTRATE	SILT SAND		SAND RUBBLE			
DEPTH	5		3		4	

APPENDIX C

ZOOPLANKTON

Appendix Table C.1. Comparision of species distribution among three major habitat types within the Hartwell District. (An X indicates that species was present)

	Lentic Habitats	Ditches	Bordering Creeks
Station No.	7,8	1-6	9-10
Taxa			
Rotifers			
Asplanchia spp.	X	X	
Branchionus angularis		X	X
B. bidentata		X	
B. budapestinensis		X	
B. caudatus	X		X
B. calyciflorus		X	
B. havanaensis	X		
B. quadridentatus	X		
B. urceolaris	X	X	
Cephalodella spp.	X		X
Euchlaris spp.		X	
Filinia longiseta	X	X	X
Karatella cochlearis	X	X	X
K. valga			X
Lecane spp.	X	X	
Lepadella spp.	X		
Monostyla spp.	X	X	
Mitilina spp.	X		
Notholca spp.		X	
Platyias patulus	X	X	
P. quadricornis		X	
Polyarthra spp.	X	X	X
Synchaeta spp.	X	X	X
Testudinella spp.	X		
Trichocera spp.	X	X	X
Trochosphaera solstitialis	X		
Bdelloid rotifer	X	X	
Copepods			
Cyclopoid copepodid	X	X	X
Eucyelops agilis	X		
Nauplii	X	X	X
Cladocerans			
Alona spp.	X		X
Ceriodaphnia spp.	X	X	
Macrothrix laticornis		X	
Moina brachiata		X	

Appendix C.2. Summary of zooplankton collected at each of six drainage ditches within the Hartwell District. See Figure 1 for sampling station locations.

	STATION 1		STATION 2		STATION 3		STATION 4		STATION 5		STATION 6		MEAN	
	NO/ LITER	% OCCUR	NO/ LITER	% OCCUR	NO/ LITER	% OCCUR	NO/ LITER	% OCCUR	NO/ LITER	% OCCUR	NO/ LITER	% OCCUR	NO/ LITER	% OCCUR
ROTIFERA	319	87.2	19	56.7	22	57.1	13	80.0	506	97.6	12	84.6	149	90.3
ASPLANCHNA SPP	8	2.1	0	0.0	0	0.0	1	6.7	8	1.5	0	0.0	3	1.7
BRACHIONUS ANGULARIS	1	.3	1	3.3	0	0.0	1	6.7	0	0.0	0	0.0	<1	.3
BRACHIONUS BIDENTATA	0	0.0	1	3.3	0	0.0	1	6.7	0	0.0	1	7.7	<1	.3
BRACHIONUS BURKEFIELDENSIS	4	1.2	0	0.0	0	0.0	1	6.7	0	0.0	0	0.0	<1	.6
BRACHIONUS CALYCIFLORUS	1	.3	0	0.0	0	0.0	0	0.0	257	49.6	0	0.0	43	26.1
BRACHIONUS URCEOLARIS	0	0.0	0	0.0	0	0.0	0	0.0	60	11.6	0	0.0	10	6.1
EUCHLANIS SPP	0	0.0	3	10.0	0	0.0	0	0.0	1	.2	0	0.0	<1	.5
FILINIA LONGISETA	8	2.1	0	0.0	0	0.0	0	0.0	7	1.3	2	15.4	3	1.7
KERATELLA COCHLEARIS	0	0.0	1	3.3	0	0.0	0	0.0	0	0.0	0	0.0	<1	.1
LECANE SPP	0	0.0	2	6.7	1	2.9	0	0.0	1	.2	0	0.0	<1	.5
MONOSTYLA SPP	3	.9	3	10.0	1	2.9	0	0.0	0	0.0	1	7.7	1	.9
NOTHOLCA SPP	0	0.0	0	0.0	1	2.9	0	0.0	0	0.0	0	0.0	<1	.1
PLATYIAS PATULUS	3	.9	0	0.0	4	11.4	0	0.0	0	0.0	1	7.7	1	.9
PLATYIAS QUADRICORNIS	3	.9	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	<1	.3
POLYARTHRA SPP	270	73.9	6	16.7	6	14.3	7	40.0	80	15.5	1	7.7	61	37.4
SYNCHAETA SPP	3	.9	1	3.3	1	2.9	2	13.3	83	16.1	1	7.7	15	9.3
TRICHOCERCA SPP	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	2	15.4	<1	.2
UNID BDELLOID ROTIFER	13	3.6	0	0.0	8	20.0	0	0.0	9	1.7	2	15.4	5	3.3
COPEPODA	11	3.0	9	26.7	17	42.9	0	0.0	12	2.4	2	15.4	9	5.2
CYCLOPOID COPEPODID	1	.3	0	0.0	0	0.0	0	0.0	4	.9	1	7.7	1	.7
NAUPLII	10	2.7	9	26.7	17	42.9	0	0.0	8	1.5	1	7.7	7	4.5
CLADOCERA	36	9.7	6	16.7	0	0.0	3	20.0	0	0.0	0	0.0	7	4.5
CERIODAPHNIA SPP	36	9.7	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	6	3.6
MACROTHRIX LATICORNIS	0	0.0	0	0.0	0	0.0	1	6.7	0	0.0	0	0.0	<1	.1
MOINA SPP	0	0.0	6	16.7	0	0.0	1	6.7	0	0.0	0	0.0	1	.7
MOINA BRACHIATA	0	0.0	0	0.0	0	0.0	1	6.7	0	0.0	0	0.0	<1	.1
TOTAL DENSITY	366		33		39		17		518		14		164	
TOTAL NUMBER OF TAXA	14		10		8		9		11		10		24	
SHANNON-WIENER INDEX	1.11		2.04		1.62		1.90		1.50		2.25		1.95	

WAPORA

Appendix C.3. Summary of zooplankton collected from the bordering creeks of the Hartwell District. Apple Creek (9) and Hurricane (10).

	STATION 9 NO/ LITER	STATION 9 % OCCUR	STATION 10 NO/ LITER	STATION 10 % OCCUR	MEAN NO/ LITER	MEAN % OCCUR
ROTIFERA	28	86.2	12	55.0	20	73.5
BRACHIONUS ANGULARIS	0	0.0	1	5.0	< 1	2.0
BRACHIONUS CAUDATUS	1	3.4	0	0.0	< 1	2.0
CEPHALODELLA SPP	0	0.0	1	5.0	< 1	2.0
FILINIA LONGISETA	0	0.0	1	5.0	< 1	2.0
KERATELLA COCHLEARIS	16	48.3	6	25.0	11	38.8
KERATELLA VALGA	4	13.8	0	0.0	2	8.2
POLYARTHRA SPP	2	6.9	1	5.0	2	6.1
SYNCHAETA SPP	1	3.4	2	10.0	2	6.1
TRICHOCERCA SPP	3	10.3	0	0.0	2	6.1
COPEPODA	3	10.3	9	40.0	6	22.4
CYCLOPOID COPEPODID	0	0.0	1	5.0	< 1	2.0
NAUPLII	3	10.3	8	35.0	6	20.4
CLADOCERA	1	3.4	0	0.0	< 1	2.0
ALONA SPP	1	3.4	0	0.0	< 1	2.0
MACROINVERTEBRATE DRIFT	0	0.0	1	5.0	< 1	2.0
NEMATODA	0	0.0	1	5.0	< 1	2.0
TOTAL DENSITY	32		22		27	
TOTAL NUMBER OF TAXA	8		9		13	
SHANNON-WIENER INDEX	1.63		1.84		1.97	

Appendix C.4. Summary of zooplankton collected from two lentic habitats within the Hartwell District. Sand Hole Pond (7) and Brushy Lake Swamp (8).

	STATION 7 NO/ LITER	STATION 7 % OCCUR	STATION 8 NO/ LITER	STATION 8 % OCCUR	MEAN NO/ LITER	MEAN % OCCUR
ROTIFERA	1032	99.8	213	72.7	623	93.8
ASPLANCHNA SPP	41	4.0	1	.4	21	3.2
BRACHIONUS SPP	0	0.0	3	1.1	2	.3
BRACHIONUS CAUDATUS	2	.2	0	0.0	1	.2
BRACHIONUS HAVANAENSIS	197	19.0	0	0.0	98	14.8
BRACHIONUS QUADRIDENTATUS	1	.1	0	0.0	< 1	.1
BRACHIONUS URCEOLARIS	1	.1	0	0.0	< 1	.1
CEPHALODELLA SPP	0	0.0	9	3.0	4	.7
FILINIA LONGISETA	3	.3	2	.8	3	.4
KERATELLA COCHLEARIS	719	69.5	1	.4	360	54.2
LECANE SPP	0	0.0	22	7.6	11	1.7
LEPADELLA SPP	0	0.0	3	1.1	2	.3
MONOSTYLA SPP	0	0.0	27	9.1	13	2.0
MYTILINA SPP	0	0.0	10	3.4	5	.8
PLATYIAS PATULUS	0	0.0	7	2.3	3	.5
POLYARTHRA SPP	42	4.1	0	0.0	21	3.2
SYNCHAETA SPP	16	1.5	26	8.7	21	3.1
TESTUDINELLA SPP	1	.1	9	3.0	5	.8
TRICHOCERCA SPP	3	.3	0	0.0	2	.3
TROCHOSPHAERA SOLSTITIALIS	0	0.0	49	16.7	24	3.7
UNID BDELLOID ROTIFER	6	.5	44	15.2	25	3.8
COPEPODA	2	.2	72	24.6	37	5.6
CYCLOPOID COPEPODID	0	0.0	17	5.7	8	1.3
EUCYCLOPS AGILIS	0	0.0	11	3.8	6	.8
NAUPLII	2	.2	44	15.2	23	3.5
CLADOCERA	0	0.0	4	1.5	2	.3
ALONA SPP	0	0.0	3	1.1	2	.3
CERIODAPHNIA SPP	0	0.0	1	.4	< 1	.1
MACROINVERTEBRATE DRIFT	0	0.0	3	1.1	2	.3
NEMATODA	0	0.0	3	1.1	2	.3
TOTAL DENSITY	1034		293		664	
TOTAL NUMBER OF TAXA	13		20		26	
SHANNON-WIENER INDEX	1.00		2.50		1.81	

APPENDIX D

PHYTOPLANKTON

Appendix D.1. Summary of phytoplankton collected at each of six drainage ditches within the Hartwell District. See Figure 1 for sampling station locations.

	STATION 1		STATION 2		STATION 3		STATION 4		STATION 5		STATION 6		MEAN	
	NO/ML	% OCCUR	NO/ML	% OCCUR	NO/ML	% OCCUR	NO/ML	% OCCUR	NO/ML	% OCCUR	NO/ML	% OCCUR	NO/ML	% OCCUR
CHLOROPHYTA	489	17.4	231	65.2	3588	80.4	77	31.6	4469	91.6	4098	36.1	2192	54.1
ACTINASTRUM HANTZSCHII	0	0.0	0	0.0	0	0.0	0	0.0	196	3.8	236	2.1	72	1.8
ANKISTRODESMUS FALCARUS	163	5.8	0	0.0	2161	48.4	0	0.0	459	9.0	383	3.4	528	13.0
CHLAMYDOMONAS SP	224	8.0	226	63.8	326	7.3	54	22.1	41	.8	2152	19.0	504	12.4
CHLOROCOCCUM ELONGATUM	0	0.0	0	0.0	224	5.0	0	0.0	0	0.0	265	2.3	82	2.0
CHODATELLA QUADRISETA	0	0.0	0	0.0	0	0.0	0	0.0	20	.4	29	.3	8	.2
CRUCIGENIA LAUTERBORNEI	10	.4	0	0.0	0	0.0	0	0.0	224	4.4	0	0.0	39	1.0
CRUCIGENIA TETRAPEDIA	0	0.0	0	0.0	0	0.0	0	0.0	20	.4	0	0.0	3	.1
DICTYOSPHAERIUM PULCHELLUM	0	0.0	0	0.0	61	1.4	0	0.0	2202	43.2	0	0.0	377	9.3
EUDORINA ELEGANS	0	0.0	0	0.0	0	0.0	3	1.1	0	0.0	0	0.0	< 1	.0
GONIUM PECTORALE	0	0.0	0	0.0	0	0.0	5	2.1	0	0.0	0	0.0	< 1	.0
KIRCHNERIELLA SP	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	29	.3	5	.1
KIRCHNERIELLA OBESA	0	0.0	0	0.0	20	.5	0	0.0	0	0.0	0	0.0	3	.1
MICRACTINIUM PUSILLUM	51	1.8	0	0.0	469	10.5	0	0.0	612	12.0	236	2.1	228	5.6
OOCYSTIS SP	0	0.0	0	0.0	41	.9	0	0.0	10	.2	29	.3	13	.3
PANDORINA MORUM	10	.4	0	0.0	0	0.0	15	6.3	0	0.0	0	0.0	4	.1
SCENEDESMUS BIJUGA	0	0.0	0	0.0	20	.5	0	0.0	0	0.0	88	.8	18	.4
SCENEDESMUS DIMORPHUS	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	29	.3	5	.1
SCENEDESMUS QUADRICAUDA	0	0.0	0	0.0	0	0.0	0	0.0	10	.2	0	0.0	2	.0
SCHROEDERIA SETIGERA	31	1.1	5	1.4	204	4.6	0	0.0	428	8.4	442	3.9	185	4.6
SPERMATOZOOPSIS EXULTANS	0	0.0	0	0.0	0	0.0	0	0.0	306	6.0	118	1.0	71	1.7
TETRASTRUM GLABRUM	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	29	.3	5	.1
TREUBARIA SETIGERUM	0	0.0	0	0.0	0	0.0	0	0.0	143	2.8	29	.3	29	.7
WESTELLA BOTRYOIDES	0	0.0	0	0.0	61	1.4	0	0.0	0	0.0	0	0.0	10	.3
BACILLARIOPHYTA	71	2.5	36	10.1	347	7.8	0	0.0	163	3.2	2772	24.4	565	13.9
CYCLOTELLA SP	0	0.0	0	0.0	265	5.9	0	0.0	112	2.2	1917	16.9	382	9.4
GYROSIGMA SP	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	29	.3	5	.1
MELOSIRA BINDERANA	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	29	.3	5	.1
MELOSIRA GRANULATA	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	29	.3	5	.1
NAVICULA SPP	41	1.4	15	4.3	41	.9	0	0.0	0	0.0	59	.5	26	.6
NAVICULA CRYPTOCEPHALA	0	0.0	0	0.0	0	0.0	0	0.0	10	.2	0	0.0	2	.0
NITZSCHIA SP	20	.7	21	5.8	41	.9	0	0.0	41	.8	501	4.4	104	2.6
NITZSCHIA ACICULARIS	10	.4	0	0.0	0	0.0	0	0.0	0	0.0	59	.5	12	.3
NITZSCHIA PALEA	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	147	1.3	25	.6

Appendix D.1. Con't.

CYANOPHYTA	10	.4	5	1.4	204	4.6	3	1.1	41	.8	295	2.6	93	2.3
ANABAENA SP	0	0.0	0	0.0	0	0.0	3	1.1	0	0.0	0	0.0	< 1	.0
ANACYSTIS SP	10	.4	5	1.4	183	4.1	0	0.0	31	.6	295	2.6	87	2.2
OSCILLATORIA SP	0	0.0	0	0.0	0	0.0	0	0.0	10	.2	0	0.0	2	.0
PHORMIDIUM SP	0	0.0	0	0.0	20	.5	0	0.0	0	0.0	0	0.0	3	.1
CRYPTOPHYTA	1998	71.0	62	17.4	306	6.8	146	60.0	71	1.4	3135	27.8	936	23.6
CHROOMONAS ACUTA	0	0.0	0	0.0	0	0.0	3	1.1	10	.2	118	1.0	22	.5
CRYPTOMONAS EROSA	1998	71.0	62	17.4	306	6.8	144	58.9	61	1.2	3037	26.8	935	23.1
CHRYSOPHYTA	0	0.0	0	0.0	0	0.0	5	2.1	31	.6	206	1.8	40	1.0
MALLOMONAS AKROKOMOS	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	29	.3	5	.1
MALLOMONAS TONSURATA	0	0.0	0	0.0	0	0.0	5	2.1	31	.6	59	.5	16	.4
OCHROMONAS SP	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	88	.8	15	.4
SYNURA SP	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	29	.3	5	.1
EUGLENOPHYTA	245	8.7	21	5.8	20	.5	8	3.2	122	2.4	796	7.0	282	5.0
EUGLENA SP	183	6.5	10	2.9	0	0.0	5	2.1	71	1.4	619	5.5	148	3.7
TRACHELOMONAS SP	61	2.2	10	2.9	20	.5	3	1.1	51	1.0	177	1.6	54	1.3
PYRRHOPHYTA	0	0.0	0	0.0	0	0.0	5	2.1	0	0.0	0	0.0	< 1	.0
GLENODINIUM SP	0	0.0	0	0.0	0	0.0	5	2.1	0	0.0	0	0.0	< 1	.0
XANTHOPHYTA	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	29	.3	5	.1
OPHIOCYTIUM CAPITATUM V LONGISPINUM	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	29	.3	5	.1
TOTAL DENSITY	2814		355		4465		244		5097		11352		4054	
TOTAL NUMBER OF TAXA	13		8		17		11		23		32		46	
SHANNON-WIENER INDEX	1.17		1.22		1.90		1.34		2.06		2.41		2.60	

Appendix D.2. Summary of phytoplankton collected from the bordering creeks of the Hartwell District. Apple Creek (9) and Hurricane Creek (10).

	STATION 9		STATION 10		MEAN	
	NO/ML	% OCCUR	NO/ML	% OCCUR	NO/ML	% OCCUR
CHLOROPHYTA	206	16.9	8	15.8	107	16.8
ACTINASTRUM HANTZSCHII	21	1.7	0	0.0	10	1.6
ANKISTRODESMUS FALCATUS	46	3.8	0	0.0	23	3.7
CHLAMYDOMONAS SP	57	4.6	5	10.5	31	4.9
CRUCIGENIA CRUCIFERA	0	0.0	3	5.3	1	.2
CRUCIGENIA TETRAPEDIA	5	.4	0	0.0	3	.4
DICTYOSPHAERIUM PULCHELLUM	10	.8	0	0.0	5	.8
ELAKATOTHRIX VIRIDIS	5	.4	0	0.0	3	.4
MICRACTINIUM PUSILLUM	36	3.0	0	0.0	18	2.8
PANDORINA MORUM	5	.4	0	0.0	3	.4
SCENEDESMUS BIJUGA	5	.4	0	0.0	3	.4
SCENEDESMUS QUADRICAUDA	15	1.3	0	0.0	8	1.2
BACILLARIOPHYTA	113	9.3	3	5.3	58	9.1
CYCLOTELLA SP	51	4.2	0	0.0	26	4.1
MELOSIRA AMBIGUA	10	.8	0	0.0	5	.8
NAVICULA CRYPTOCEPHALA	5	.4	0	0.0	3	.4
NAVICULA RHYNCHOCEPHALA	0	0.0	3	5.3	1	.2
NITZSCHIA SP	26	2.1	0	0.0	13	2.0
NITZSCHIA ACICULARIS	15	1.3	0	0.0	8	1.2
NITZSCHIA HOLSATICA	5	.4	0	0.0	3	.4
CYANOPHYTA	493	40.5	28	57.9	261	41.2
ANABAENA SP	5	.4	0	0.0	3	.4
ANACYSTIS SP	10	.8	0	0.0	5	.8
APHANIZOMENON FLOS-AQUAE	5	.4	0	0.0	3	.4
OSCILLATORIA SP	473	38.8	28	57.9	250	39.6

Appendix D.2. Con't.

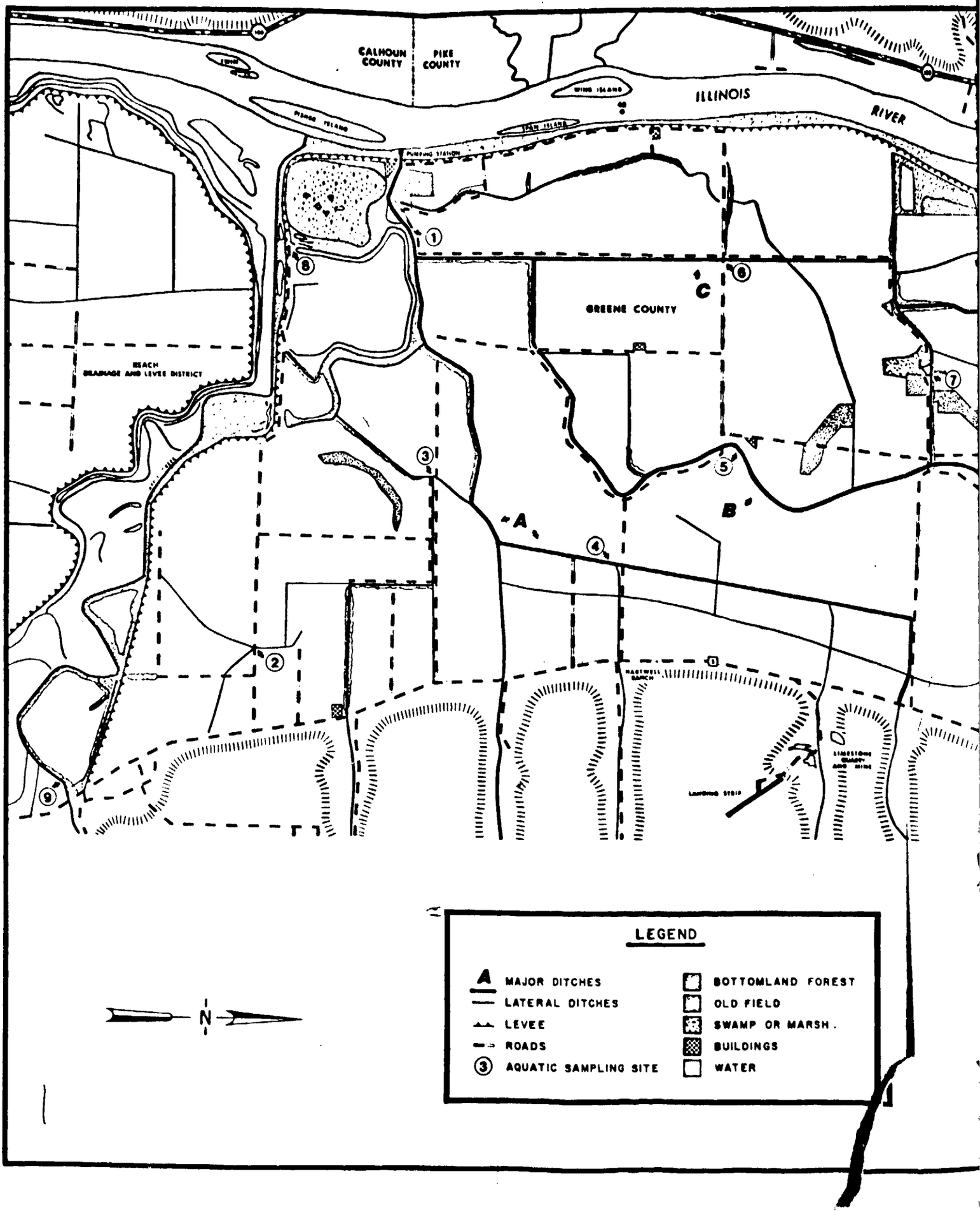
CRYPTOPHYTA	144	11.8	8	15.8	76	12.0
CHROOMONAS ACUTA	15	1.3	0	0.0	8	1.2
CRYPTOMONAS EROSA	128	10.5	8	15.8	68	10.8
CHRYSOPHYTA	10	.8	0	0.0	5	.8
MALLOMONAS TONSURATA	5	.4	0	0.0	3	.4
SYNURA SP	5	.4	0	0.0	3	.4
EUGLENOPHYTA	247	20.3	3	5.3	125	19.7
EUGLENA SP	134	11.0	0	0.0	67	10.5
PHACUS SP	5	.4	0	0.0	3	.4
TRACHELOMONAS SP	108	8.9	3	5.3	55	8.7
PYRRHOPHYTA	5	.4	0	0.0	3	.4
CERATIUM HIRUNDINELLA	5	.4	0	0.0	3	.4
TOTAL DENSITY	1218		49		633	
TOTAL NUMBER OF TAXA	28		6		30	
SHANNON-WIENER INDEX	2.28		1.31		2.27	

Appendix D.3. Summary of Phytoplankton collected from two lentic hbitats within the Hartwell District. Sand Hole Pond (7) and Brushy Lake Swamp (8).

	STATION 7		STATION 8		MEAN	
	NO/ML	% OCCUR	NO/ML	% OCCUR	NO/ML	% OCCUR
CHLOROPHYTA	3364	24.4	3	.9	1683	23.9
ANKISTRODESMUS FALCATUS	178	1.3	0	0.0	89	1.3
CHLAMYDOMONAS SP	408	3.0	0	0.0	204	2.9
CHODATELLA QUADRISETA	25	.2	0	0.0	13	.2
CLOSTERIOPSIS LONGISSIMA	25	.2	0	0.0	13	.2
COELASTRUM SPHAERICUM	51	.4	0	0.0	25	.4
CRUCIGENIA CRUCIFERA	280	2.0	0	0.0	140	2.0
CRUCIGENIA TETRAPEDIA	561	4.1	0	0.0	280	4.0
ELAKATOTHRIX GELATINOSA	25	.2	0	0.0	13	.2
ELAKATOTHRIX VIRIDIS	25	.2	0	0.0	13	.2
KIRCHNERIELLA OBESA	51	.4	0	0.0	25	.4
MICRACTINIUM PUSILLUM	178	1.3	0	0.0	89	1.3
OOCYSTIS SP	510	3.7	0	0.0	255	3.6
PANDORINA MORUM	0	0.0	3	.9	1	.0
PEDIASTRUM TETRAS	25	.2	0	0.0	13	.2
SCENEDESMUS BIJUGA V ALTERNANS	943	6.8	0	0.0	471	6.7
SCENEDESMUS DIMORPHUS	25	.2	0	0.0	13	.2
TETRAEDRON SP	25	.2	0	0.0	13	.2
TETRAEDRON CAUDATUM	25	.2	0	0.0	13	.2
BACILLARIOPHYTA	2752	20.0	23	8.1	1388	19.7
CYCLOTELLA STELLIGERA	2498	18.1	0	0.0	1249	17.7
GOMPHONEMA SP	0	0.0	3	.9	1	.0
MELOSIRA GRANULATA	25	.2	0	0.0	13	.2
NAVICULA SPP	0	0.0	8	2.7	4	.1
NAVICULA CRYPTOCEPHALA	0	0.0	5	1.8	3	.0
NITZSCHIA SP	102	.7	5	1.8	54	.8
NITZSCHIA ACICULARIS	127	.9	0	0.0	64	.9
SYNEDRA SP	0	0.0	3	.9	1	.0
CYANOPHYTA	6320	45.8	49	17.1	3185	45.3
AGMENELLUM SP	25	.2	0	0.0	13	.2
ANABAENA SP	25	.2	0	0.0	13	.2
ANACYSTIS SP	5913	42.9	49	17.1	2981	42.4
APHANIZOMENON FLOS-AQUAE	25	.2	0	0.0	13	.2
LYNGBYA SP	331	2.4	0	0.0	166	2.4

Appendix D.3. Con't.

CRYPTOPHYTA	714	5.2	5	1.8	359	5.1
CHROOMONAS ACUTA	510	3.7	0	0.0	255	3.6
CRYPTOMONAS SP	0	0.0	5	1.8	3	.0
CRYPTOMONAS EROSA	204	1.5	0	0.0	102	1.4
CHRYSOPHYTA	102	.7	0	0.0	51	.7
MALLOMONAS TONSURATA	76	.6	0	0.0	38	.5
OCHROMONAS SP	25	.2	0	0.0	13	.2
EUGLENOPHYTA	408	3.0	206	72.1	307	4.4
EUGLENA SP	127	.9	64	22.5	96	1.4
EUGLENA ACUS	0	0.0	3	.9	1	.0
PHACUS SP	25	.2	5	1.8	15	.2
PHACUS TORTUS	0	0.0	82	28.8	41	.6
TRACHELOMONAS SP	255	1.8	51	18.0	153	2.2
PYRRHOPHYTA	102	.7	0	0.0	51	.7
CERATIUM HIRUNDINELLA	102	.7	0	0.0	51	.7
XANTHOPHYTA	25	.2	0	0.0	13	.2
OPHIOCYTIUM CAPITATUM V LONGISPINUM	25	.2	0	0.0	13	.2
TOTAL DENSITY	13787		285		7036	
TOTAL NUMBER OF TAXA	35		13		43	
SHANNON-WIENER INDEX	2.16		1.86		2.21	


CALHOUN COUNTY
PIKE COUNTY
ILLINOIS
RIVER
GREENE COUNTY
BEACH
DRAINAGE AND LEVEE DISTRICT
A
B
C
D
1
2
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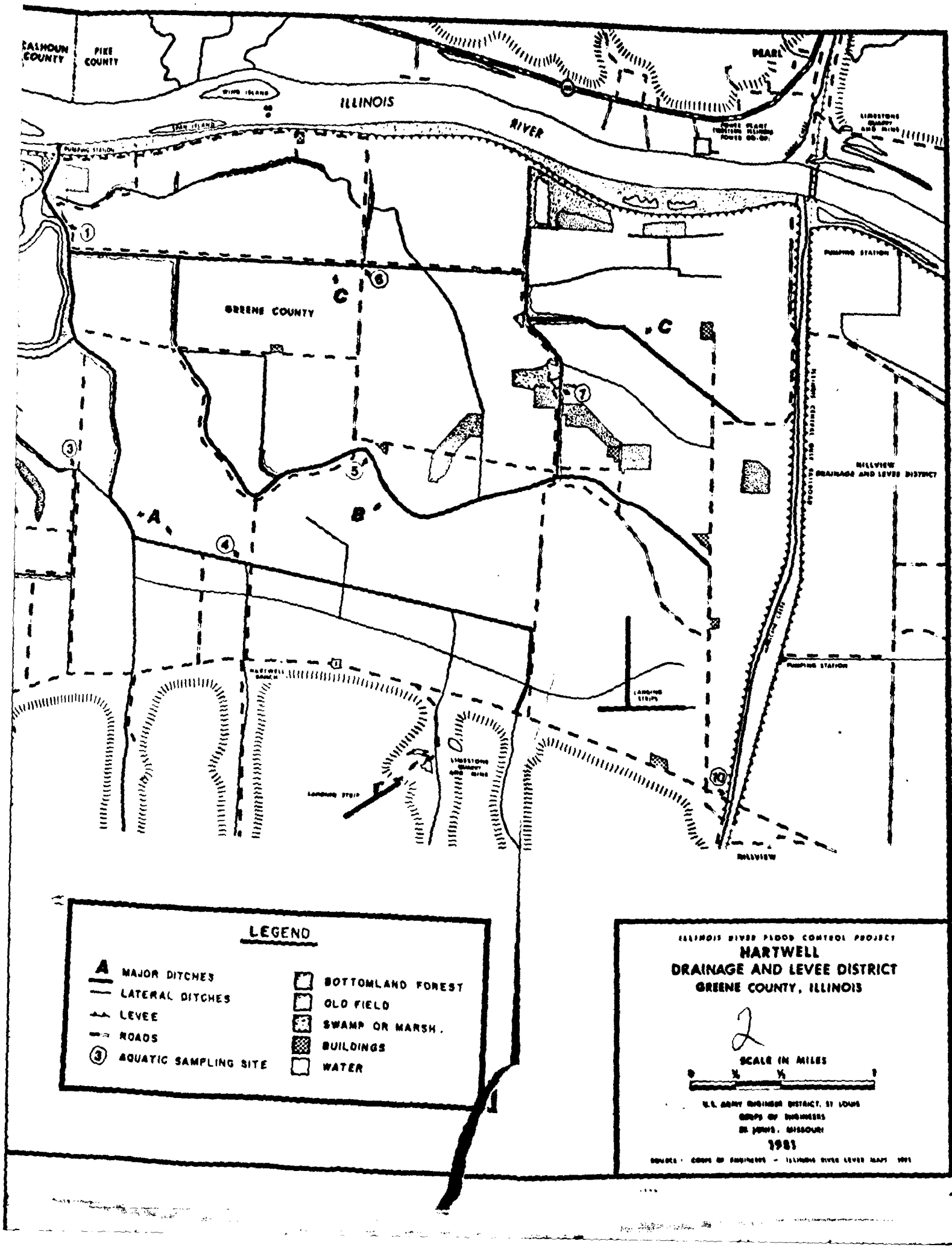
5
6
7
8
9
N
LEGEND
MAJOR DITCHES
LATERAL DITCHES
LEVEE
ROADS
AQUATIC SAMPLING SITE
BOTTOMLAND FOREST
OLD FIELD
SWAMP OR MARSH
BUILDINGS
WATER


CALHOUN COUNTY
PIKE COUNTY
ILLINOIS
RIVER
PEARL
PUMPING STATION
GREENE COUNTY
C
B
A
HILLVIEW
LANDING STRIP
LEGEND
MAJOR DITCHES
LATERAL DITCHES
LEVEE
ROADS
AQUATIC SAMPLING SITE
BOTTOMLAND FOREST
OLD FIELD
SWAMP OR MARSH.
BUILDINGS
WATER
ILLINOIS RIVER FLOOD CONTROL PROJECT
HARTWELL
DRAINAGE AND LEVEE DISTRICT
GREENE COUNTY, ILLINOIS
2
SCALE IN MILES
1981